INFECTIOUS
AND PARASITIC DISEASES

LANGFELD

"This kingdom (bacterial) is a veritable fairyland. Its inhabitants are more numerous than the sands of the sea, and as varying in their functions as are the inhabitants of the animal and vegetable kingdom." "Only a few of them work serious harm to man, and even the harm which these do is not out of harmony with nature as a whole. The world as we see it can be maintained only by a harmonious succession of life and death." (Flick, Consumption, a Curable and Preventible Disease.)

"When we realize that the majority of all deaths is still from preventible causes, most of which are already quite familiar to us, it is manifest that this must be in a large measure due to an indifference on our part to put into practice even the knowledge which we already possess for their prevention." (Abbott, Hygiene of Transmissible Diseases.)

"The belief is growing stronger that the communicable diseases are more often spread through the intermediation of mild, latent and unrecognized cases than through the agency of fomites, that is, inanimate objects." (Rosenau, Disinfection and Disinfectants.)

INTRODUCTION TO

INFECTIOUS AND PARASITIC DISEASES

INCLUDING

THEIR CAUSE AND MANNER OF TRANSMISSION

BY

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With an Introduction by Lewellys F. Barker, Professor of Medicine at the Johns Hopkins University

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WITH THIRTY-THREE ILLUSTRATIONS

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To the
memory of my beloved father
𝔇aniel 𝔏angfeld
this book in grateful remembrance
is dedicated

PREFACE.

Primarily this book was written for the use of nurses, in the belief that by broadening their comprehension of infectious and parasitic diseases it would materially assist them in performing their duties more intelligently, and with greater satisfaction to themselves. Through the solicitations of several medical friends who kindly looked over my manuscript, and who were of the opinion that both physicians and students of medicine would find as much to interest them in its pages as would nurses, the original design of the book was altered somewhat. It seemed to me that if in place of the conventional (seriatum) text-book consideration of the above diseases the fundamental principles which govern all were substituted, knowledge of wider utility would be acquired, and with less effort, because much unimportant detail could be avoided. It was my aim, also, by reflecting current medical thought to explain to nurses the reasons for performing many duties which they are merely taught to do. Then, since the trained nurse's position as medical assistant to the doctor and

as a sanitarian has developed into one of such extraordinary importance, specific information in regard to these offices was to be given a prominent place. For the same reasons, chapters on "Bacteriology," "Parasites," and "The Collection and Examination of Secretions and Excretions" were included in the plan. Withal, every effort was to be made to be lucid in style and simple in treatment. Of nursing, per se, I was not to treat.

The present volume represents my efforts to embody the above ideas in a book.

My obligation to various authors has been heavy, and I wish I could make suitable acknowledgment to every one upon whom I have drawn for material; but the character of the book obviously makes this impracticable. Nevertheless, to Professor Roger's "Introduction to the Study of Medicine" and "Infectious Diseases," to Dr. Abott's "Hygiene of Transmissible Diseases," and also to Dr. Rosenau's "Disinfection and Disinfectants," I feel reference should be made. Furthermore, I would be lacking in gratitude did I not make acknowledgment to my alma mater, the Johns Hopkins Medical School; the book really owes its inception to the scientific spirit and inspiring personality of its faculty.

To have been a student there is a life-long pleasurable memory, and a distinction which I feel can be repaid only in small measure by describing my efforts as

feeble amplifications of its teachings.   Professor Barker was my first teacher in medicine, and to him I am indebted for much more than his graciousness in reviewing these pages and writing the introductory note.

The only originality claimed is in the presentation of the subject matter.   Save in a few instances, speculation has not been indulged in, and only accepted doctrines have been adhered to.

Great pleasure was taken in the writing of these pages, although most of the work was done during moments snatched here and there between urgent duties; whether I was justified in my undertaking can only be told if others derive either pleasure or profit in their perusal.

MILLARD LANGFELD.

203 McCague Bldg., Omaha, Neb.
March 25, 1907.

INTRODUCTORY NOTE.

This volume which Dr. Langfeld has written is intended as an introduction to the subject of bacteriology, for the use of that large and increasing number of people who are interested directly or indirectly in the subject, but who have been unable to undergo any practical training in it. I have had the opportunity of reading the chapters before they went to press, and have no hesitation in recommending the book to the class of readers for which it is intended. The presentation is simple and clear, and the author has carefully avoided the use of terms and the discussion of questions which would be unintelligible to beginners in the subject. It is his hope and mine that many may be led through a study of these pages to undertake sufficient practical work in the subject of bacteriology to permit them to apply in their various occupations the principles of this science so important in connection with medicine and with the nursing of the sick.

<div align="right">Lewellys F. Barker.</div>

Baltimore, Maryland.
  March 20, 1907.

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CHAPTER I.

CAUSES OF DISEASE.

Since disease is a deviation from that state of the
body which is called health, it is appropriate, before
taking up the "causes of disease," to define, briefly,
what health and disease are.

HEALTH. Health may be defined as that condition
of the body in which all of its functions are
normally performed, to the end, that a
feeling of mental and bodily comfort is experienced. It
is a nice balance, or equilibrium, maintained between
our bodies and the surrounding world. Eating, drink-
ing, and sleeping, work, play, and rest, are factors that
should promote a general feeling of well-being, that
in turn manifests itself in the desire and ability to eat,
drink, sleep, work, play, and rest, all normal functions
which the healthy human being craves.

DISEASE. Disease, on the other hand, is characterized
by a rupture in the relationship of our
bodies to our surroundings, which leads
to disturbed functions, and to unusual subjective sen-
sations and objective phenomena. Whatever breaks

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the harmony of health, in other words, whatever causes disease, always acts so as to destroy some tissue, or to interfere with the functions of some organ. The modern conception of the causation of disease no longer gives credence to the belief that its causes are novel and mysterious, but, on the contrary, from indisputable evidence, places them among the actual phenomena of the physical world. Nor does it admit the spontaneous development of disease in either the born or the unborn, albeit obvious instances to the contrary, since in such cases some external agency has previously acted directly or indirectly (e.g., through a parent) as a first cause, and interrupted the orderly continuity of the normal functions. Therefore, no matter what the exciting cause of a disease may be, *it invariably, and primarily, comes from without the body.*

When an extraneous cause acts injuriously upon a person, his organism does not remain passive, but reacts with all its might to counteract the cause and repair any defect the latter's presence has given rise to. This power of the body to protect itself lays in a defensive mechanism evolved during countless ages of successful efforts to survive destruction against harmful influences in the universal struggle for life. So nicely is the body's mechanism of defense adjusted, that constant re-adjustments are made to passing dangers, under ordinary circumstances, without consciousness being disturbed. In this way equilibrium with the

outside world is maintained. Should, however, a harmful influence be unusually strong, then the reactions of re-adjustment to which it gives rise are correspondingly vigorous and wide-spread, so that consciousness is disturbed, functions are corrupted, and most astonishing changes in the external appearance are observed. These phenomena of reaction are evidence of the battle that is being waged by the body against a harmful force, and collectively they constitute the *symptoms of disease.* All harmful influences are provocative of disease; yet disease does not exist unless the reactions or symptoms are sufficiently pronounced as to upset the orderly unconscious functioning of the body.

Diseased states are also called *morbid* or *pathological;* wherefore morbific or pathological causes are those that bring about disease. The causes of disease are often spoken of as agents. We divide the agents of disease into four classes, *mechanical, physical, chemical, and animate.*

Mechanical. A blow which breaks a bone, an obstruction to respiration due to a foreign body lodging in the larynx, a rupture of the abdominal wall that permits a loop of the intestines to protrude, are all instances of diseases due to mechanical agents.

Physical. Similarly, alterations in the surrounding medium, as for example, ascending to great heights, or working at great depths under pressure, produce respectively mountain-climbers'

disease and divers' paralysis—two well-recognized affections, the result of physical agents.

CHEMICAL AGENTS. That diseases are often brought about through chemical agents scarcely needs illustration on account of the frequency of such cases being reported by the Press, and the familiarity of the average person with the dangerous character of many chemicals, notably the poisons. Ptomain poisoning, which comes from eating various foods that have undergone a peculiar decomposition; arsenical poisoning, numerous cases of which were reported in London, England, a few years ago, in which the arsenic was traced to the glucose in beer; and painters' colic, or lead colic, a disease common in those whose occupations bring them into close contact with lead, are examples of diseases of chemic origin. Indeed, among the causes of disease, the chemical agents are by far the most numerous and the most important, in as much as the majority of diseased states are fundamentally, or coincidentally, of a chemical nature. Most of the physical and mechanical agencies, through the injuries they inflict on tissues, are thereby transformed into chemical irritants, since the resulting reactions follow largely as a result of the absorption of dead and useless material. For example: A person is severely burned, yet survives three days. He does not die as a direct result of the physical agent, fire, but from poisoning in one of the two ways; namely,

either so large a surface of the cuticle was destroyed that the respiratory and excretory functions of the skin were interrupted, so that poisoning followed the retention of products which should have been excreted from the body; or, poisoning resulted from absorption of the detrimental products into which the skin was converted by the fire.

Similarly, in diseases the result of mechanical forces, while the earliest phenomena are the direct result of the injury (shock, for example), the later reactions follow as a sequel to the absorption of dead tissues and inflammatory products. Indeed, reconstruction of tissues, e.g., bone, etc., is initiated by these very products being absorbed, and, thereby reflexly irritating into action those tissues and functions that bring about repair.

ANIMATE AGENTS. The fourth group into which we divide the agents of disease is the animate. Animate agents comprise two classes, parasites and infectious agents, both of which may be found among either the animal or vegetable kingdom.

INFECTIOUS AGENTS. Before the dawn of bacteriology, physicians had already applied the term, infectious, to diseases that, symptomatically, conformed to a certain type and were conveyed through the air. Early in their career, bacteriol-

ogists discovered that a number of the infectious diseases were due to bacteria and, rather hastily, it must be confessed, concluded that all of this class had a similar origin. So they described an infectious disease as "a morbid or diseased state of the body due to the invasion and growth of bacteria." Somewhat later it was seen that they had gone too far in formulating this definition for infectious diseases, because a certain number were discovered which owe their origin to animate agents that are not bacteria, namely, to moulds and protozoa.*

Hence it has followed that the designation "infectious disease" is restricted in its application to diseases which conform to a certain type, and "infectious agent" to a living organism,† microscopic in size, that is capable of producing an infectious disease. So far as we know, only three types of organisms produce infectious diseases, namely, bacteria, moulds and protozoa, certain species of each comprising the infectious agents. At present bacteria constitute the vast majority, but it is fast

* Protozoa (literally, first animal) are the simplest organisms which clearly belong to the animal kingdom. The characteristic which distinguishes them from all other groups of animals is the fact that each protozoan consists of a single cell.

† Organism—composed of organs functionally necessary for the existence of the individual or race. Although unicellular plants and animals have no organs, yet, since they perform functions analogous to those of the higher forms of living matter, we are correct in considering them organisms.

becoming evident that both protozoa and moulds are of almost, if not of equal importance, as causative factors in infectious diseases; and that besides these, there are other microscopic and ultra-microscopic forms of life, not included in the three groups, that are playing a similar rôle.   For these reasons we conclude that the only defensible definition of an infectious agent is that it is either an animal or vegetable organism, microscopic in size, which produces an infectious disease.   It will be observed, from the point of view of this definition, that we classify the organisms that produce infectious diseases not by their place in the animal or vegetable kingdom, but by the effects they produce in the living body.

The animate agents, it will be remembered, we divided into two classes, parasites, and infectious agents. The designations have reference both to the manner in which the agents live upon the body, and the phenomena their presence give rise to; their place in either animal or vegetable kingdom is again disregarded. The mode of action of the infectious agent is characteristic, and markedly different from that of the parasite. When it enters a living body, it aims directly at the destruction of the latter.   It multiplies rapidly, tends to scatter its broods throughout the tissues, and all the while gives off the most powerful poisons known. This agent is wickedly implacable, neither giving nor asking quarter.   The battle that it wages with the body

can terminate only by the destruction of one of the combatants.

PARASITE. In contrast to this monster evil is the lesser, the parasite. A parasite is an organism that lives within or upon another organism called the host. The parasite's purpose is an easy living at the expense of the host. It subtly recognizes that it is to its interest not to inflict too great an injury. If perchance it causes the death of the host, it is an accident. It seldom invades the body generally. From the foregoing is seen the reason for drawing a distinction between parasites and infectious agents *based upon their mode of action and the effects they produce.* It should be remembered, however, that parasites and infectious agents are not necessarily represented by distinct organisms. Indeed, the same microbe may live upon our bodies, or within its cavities, at one time as a parasite, and at another time be the cause of an infectious disease. The germ of pneumonia is a constant inhabitant of almost everyone's mouth, leading there a harmless parasitic existence, yet let the vital powers be reduced through fatigue, exposure, or cold, and it becomes an infectious agent through the disease (pneumonia) which it provokes. The difference between a germ that is at one time a parasite, and at another time an infectious agent, depends in the latter case upon the power it has of producing its specific poison, and also upon its chance

of finding lodgment in an appropriate situation within the body.*

SPECIFIC AND NON-SPECIFIC INFECTIOUS AGENTS. Infectious agents are divided into those that are *specific*, and those that are *non-specific*. By specific is understood an organism that always provokes the same disease; at the same time it implies that it is the only exciting cause of that disease. The microbes which cause typhoid fever, diphtheria, plague, etc., are specific agents, because they are the only germs, respectively, that can give rise to these diseases.

A non-specific agent is an organism whose entrance into the body is not necessarily followed by the same disease, in fact, its effects are particularly characterized by their dissimilarity; besides, its action is duplicated by other non-specific agents. The streptococcus pyogenes is a most excellent example of a non-specific agent. The following are some of the diseases it provokes: Erysipelas, puerperal fever (child-bed fever), tonsillitis, peritonitis, abscess, etc., all affections that exhibit a widely divergent symptomatology, and each one of which may result from entrance into the body of an entirely different species of bacterium.

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*From one view-point, all infectious agents are parasites, just as we will see later they may also be saprophytes. But the true parasite is never an infectious agent.

SPECIFIC AND NON-SPECIFIC INFECTIOUS DISEASES. Infectious diseases are divided into the specific and the non-specific according as they result from a specific or non-specific agent. There are some infectious diseases, however, in which the etiological factor is not known, yet they are classed with the specific maladies. This is done because the symptomatology of each is characteristic, and because any one of them in one individual never gives rise in another, who may contract it, to a different disease. In this class of specific diseases, of which the causes are not known, is small-pox, scarlet fever, measles, chicken-pox, etc. These same diseases are also classed as infectious, but entirely, it should be noted, on account of their close resemblance to those infectious diseases whose determining factor is positively known to be a micro-organism.

In the list of infectious diseases of known and unknown etiology which follows, it will perhaps come as a surprise to the student that the cause of so many diseases is as yet unknown; and that those of unknown etiology include many of our most common diseases. He might well ask the question, why have the causes of these every-day diseases not been discovered? There are probably two chief reasons: First, because the causes have been sought for as if they must be bacteria, whereas they very likely belong to entirely different genuses of organisms; and second, because the causes

of some diseases, at least, are probably ultra-microscopic, i.e., too minute to be made out with the magnifying powers of the present microscope.

It will also be noticed that syphilis is placed under both groups. This is done because, from the evidence accumulated thus far, it seems quite probable that the treponema pallidum (*spirochæta pallida*) of Schaudinn and Hoffman is the etiological factor.

SPECIFIC INFECTIOUS DISEASES OF KNOWN ORIGIN.

GONORRHŒA.
EPIDEMIC CEREBRO - SPINAL MENINGITIS.
PNEUMONIA (Lobar).
TUBERCULOSIS.
LEPROSY.
GLANDERS (Farcy).
TETANUS (Lock-jaw).
DIPHTHERIA.
ASIATIC CHOLERA.
ANTHRAX.
TYPHOID FEVER.
BUBONIC PLAGUE.
INFLUENZA (La Grippe).
MALTA FEVER.
RELAPSING FEVER.
ACUTE SPECIFIC DYSENTERY (Bacillary Dysentery).
ACTINOMYCOSIS.
MYCETOMA (Madura Foot).
MALARIAL FEVER.
AMŒBIC DYSENTERY.
SYPHILIS.

SPECIFIC INFECTIOUS DISEASES OF UNKNOWN ORIGIN.

EPIDEMIC PAROTITIS (Mumps).
SYPHILIS.
RABIES (Hydrophobia).
YELLOW FEVER.
MEASLES.
WHOOPING-COUGH.
SCARLATINA (Scarlet Fever).
VARIOLA (Small-pox).
TYPHUS FEVER.
VACCINIA (Cow-pox, Vaccination).
VARICELLA (Chicken-pox).
RUBELLA (Rötheln).
DENGUE (Break-bone Fever).
RHEUMATIC FEVER (Rheumatism).
BERI-BERI.
GLANDULAR FEVER (?).
APHTHOUS FEVER (Foot and Mouth Disease).
CHANCROID.
TRACHOMA (Egyptian Ophthalmia).

CHARACTER-   An infectious disease follows a cycle, or
ISTICS OF   course, which is typical of the class "infec-
INFECTIOUS   tious diseases." To be sure, there are
DISEASES.   variations from the type, sometimes very
pronounced, yet certainly never greater than one would
anticipate in view of the differences exhibited by people
in general. Moreover, the infectious agents causing
them are subject to great variations in disease-producing
power, a fact which influences the character of the
infection either for better or for worse. Concerning
these differences in pathogenicity as exhibited by infec-
tious agents, we shall have much to say in a succeeding
chapter. In this course or cycle of an infectious
disease, four stages are commonly admitted:

1. An incubation period.
2. A period of invasion.
3. A stationary period.
4. A period of decline.

These periods, or stages, of an infectious disease
were first created upon purely clinical grounds; but
they have been retained, because they are in entire
harmony with modern discovery and experiment, a
fact which adds another laurel to the fame of those dear
old practitioners who knew absolutely nothing of the
science of bacteriology. Besides, these periods as
named by them, remarkable to say, graphically describe
the progress of microbic action from the beginning of
a disease to its termination. An infectious disease

must be regarded as a battle to the death between the body, on the one hand, and an infectious agent on the other; and as the symptoms of each period correspond to various phases in the battle, we are able to recognize which side, for the nonce, has the upper hand.

INCUBATION PERIOD. The incubation period is the time that elapses between the entrance of the disease-causing microbe into the body and the onset of the symptoms.

When a person takes a drug which has the property of inducing sleep, e.g., opium, or a stimulant, such as whisky, there is observed an appreciable period between the ingestion of either, and the beginning of the phenomena which are characteristic for each drug. If we follow these phenomena, it is observed that according to the quantity taken, after they first began to appear, there is a gradual increase in the number and intensity of the symptoms to a certain point, when they are maintained for a variable period. Finally, there is a gradual lessening of the influence until the drug is eliminated from the body. After the elimination there remain such phenomena as are the result of the removal of the influence, and the re-adjustment of the economy to its normal state. The phenomena just described only follow in case a dose of sufficient size has been ingested, the amount varying, naturally, with the individual. However, when that quantity which will produce symptoms has been reached, the results are

directly dependent upon the amount taken. There is no increase of the drug within the body.

When, however, we come to study the action of an infectious agent upon the body, we find the same interval of time between the entrance of the infectious agent and the onset of the symptoms, but there is a very great difference in the events that take place to produce the reactions. The amount of opium or whisky ingested is fixed, so that whatever the effect, it results from just that amount. When infectious agents enter the body, however, they at once begin to multiply in enormous numbers, giving off all the while as a product of their activity most powerful poisons (toxins). When a sufficient amount of poison has been generated, symptoms of the disease appear. In other words, the infectious agents that gain an entrance into the body have not of themselves sufficient power to produce the disease, but act through their facility of increasing their numbers. It is self-evident, therefore, why this period is called the "incubation period," since it "corresponds to the development (multiplication) of the pathogenic agents." Clinically the incubation period is also known as the *latent period*.

The incubation period varies as to time in different diseases, and in different cases of the same disease. It may only be a few hours, as in erysipelas, or it may extend over months and years, as in hydrophobia and leprosy. This period is of very great importance from

a hygienic standpoint, in that it affects the length of quarantine imposed upon individuals exposed to contagious diseases. The following table taken principally from Roger's "Infectious Diseases" is worthy of careful study.

INCUBATION PERIOD OF VARIOUS INFECTIOUS DISEASES.

	Average.		Minimum.	Maximum.	
Anthrax	2	days	1 day	3	days
Bubonic Plague	4–6	"	2 "	7	"
Chancroid	1–2	"	1 "	3	"
Cholera	2–4	"	1 "	6	"
Diphtheria	2	"	2 "	15	"
Erysipelas	4–6	"	3 hours	22	"
Influenza	3–4	"	1 day	5	"
Glanders	3–5	"	24 hours	3	months
Gonorrhœa	3–5	"	1 (?)–2 days	1–several	weeks
Mumps	15	"	7 days	30	days
Malarial Fever	6–10	"	99 hours	several	months
Recurrent Fever	5–6	"	86 "	8	days
Measles	9	"	4 days	14	"
Hydrophobia	20–60	"	13 "	18 mos. to 3 yrs	
Rubeola	18	"	5 "	21	days
Scarlatina	2–5	"	7 hours	7	weeks
Small-pox	12	"	7 days	15	days
Syphilis	20–30	"	10 "	50	"
Tetanus (Lock-jaw)	2–3	"	2 hours	35	"
Typhoid Fever	14	"	2 days (?)	21	"
Typhus Fever	12	"	0 (?)	23	"
Vaccinia	3	"	2 days	7	"

	AVERAGE.	MINIMUM.	MAXIMUM.
Varicella	14–15 days	13 days	19 days
Whooping-cough	8 "	2 "	8 "
Yellow Fever	3–4 "	2 "	6 "
Leprosy	(?)	(?)	32 years
Tuberculosis	(?) incubation period frequently long.		
Dengue	4 days	3 days	5 days
Pneumonia	24 hours	(?)	2 or more days
Dysentery (Bacillary)	8 days	6 days	48 hours
Malta Fever	6–10 "	(?)	10 days
Beri-beri	Several months (?)		

During the incubation period symptoms
PERIOD OF   are wanting, and, as far as the person is
INVASION.   aware, he experiences nothing to indicate
that he is not in normal health. When,
however, the body awakens to the impending danger, it
brings its defensive forces into play in an effort to throw
off the infectious agents and their toxins. Clinically,
these reactions are represented by the first symptoms
of disease, and are known as the "symptoms of onset."
They indicate that invasion of the body by an infectious
agent has taken place. It is for this reason that this
period is spoken of as the period of invasion.

The period of invasion also differs in various diseases,
and in various cases of the same disease. The symp-
toms of invasion may appear with startling suddenness,
as the chill which occurs at the onset of pneumonia, or
the convulsion in children which initiates most of the
eruptive fevers; or they may develop so gradually as

to make it impossible for the patient to say when he really began to feel ill. This slow insidious manner of onset is the rule in typhoid fever and pulmonary tuberculosis.

STATIONARY PERIOD. After the period of invasion comes the stationary period, the symptoms of which are so characteristic for each particular infectious disease as to form the basis for our classification of infectious diseases in general, and of identification of any one in particular. If the invasion be sudden, the stationary period is usually quickly reached (in pneumonia, a few hours); if gradual, the stationary period may be prolonged a week or more (e.g., typhoid fever). The stationary period presents more or less uniformity in symptoms, with ameliorations or aggravations of the symptoms corresponding to oscillations of advantage of either body or germ.

Variations from the type of the stationary period in any infectious disease also occur with a fair degree of frequency. The stationary period may be cut short by the body-forces being marshaled at the onset, and the disease end there; or it may be prolonged far beyond the average limits for the disease. On the other hand, the microbes may get the upper hand from the start, stifle (in their incipiency) the body's efforts to react and close the picture even before the stationary period had really begun. However, these courses are not

typical; in the typical case, unless the battle is decided in favor of the microbes, the stationary period passes into the *period of decline*.   Where the stationary period of any disease is abbreviated by recovery, we speak of the disease as having been aborted; where abbreviation or prolongation of any disease occurs, or where marked variations from the type take place, the disease is spoken of as having pursued an aberrant form.

PERIOD OF DECLINE.   The period of decline is expressive of the victory that the body has won over the infecting agents.   This period is taken up with the physiological re-adjustments and anatomical repairs necessary to bring the body back to health.

CRISIS AND LYSIS.   Precisely as the onset of a disease may be either sudden or gradual, so may the decline be characterized either by a most astonishingly rapid amelioration of the symptoms, or by slow, progressive improvement.   In the former case we speak of termination of the disease by *crisis*, in the latter, by *lysis*.

Termination by crisis is well illustrated by pneumonia, termination by lysis, by typhoid fever.   Crisis is perhaps the most peculiar and mystifying phenomenon that ever occurs in disease.   Always awaited with so much anxiety, when it has happened it may well be joyously received, since it conveys to the physician the knowledge that recovery, *"of which it is the result,"*

not the cause, has been effected. And the same is true of lysis, it is the harbinger of the fact that the infectious agents are being vanquished. In the matter of termination, the rule is not always followed; accordingly, we sometimes find pneumonia terminating by lysis, and less often, typhoid fever by crisis. One curious exception to the usual form that crisis takes, i.e., reduction in temperature, occurs in Asiatic cholera. Instead of the temperature falling, it rises from below normal (sub-normal) to normal or above normal. The characteristic feature of the crisis is thus reversed, a thing which is associated with the other reversal that takes place in the stationary period of cholera, i.e., a sub-normal temperature.

LOCAL AND GENERAL INFECTIONS. An infectious disease is due to the entrance and growth of infectious agents, and to the toxins (poisons) which the latter generate. When infectious agents gain an entrance into the body, they act in one of two ways, namely:

(1) Either they remain localized near their portal of entry, or in some near or distant organ, during the whole course of the disease; or,

(2) they first establish a local lesion near their portal of entry, or in some near or distant organ, and then, from this as a focus, invade the whole body.

The first instance is descriptive of what is called a *local infection*, the second, of a *general infection*. In

both cases the toxins play the same important rôle; yet while in the one they are formed in only one portion of the body, in the other, since the infectious agents are scattered, they are formed in all parts. Infectious diseases which result from toxins eliminated by micro-organisms growing in a circumscribed area are known as *toxæmias*, while those in which the micro-organisms live and multiply in the blood-stream are called *septicæmias* (in cases in which bacteria are the invaders, *bacteriæmias*). A general infection, therefore, corresponds to a septicæmia, or bacteriæmia. It must not be inferred, however, that a toxæmia always accompanies a local infection, for there are many local infections in which the action of the agents and their toxins are purely local; the word toxæmia is reserved for local infections associated with constitutional symptoms of poisoning. To illustrate: No one would call an abscess an infectious disease, although it represents the localized activity of certain bacteria, and is therefore correctly spoken of as a local infection. On the other hand, tetanus, a constitutional disease, has as its local infection a wound, frequently so trivial, that it has healed before the convulsions begin which mark the onset of this terrible disease. It is the toxins formed by the bacilli at one point, and absorbed, which give rise to the toxæmia.

A local, or a general infection, may be caused by either a specific or a non-specific infectious agent, but not by

any specific or non-specific agent. Some specific agents only give rise to local infectious diseases (toxæmias), while others only to septicæmias (or bacteriæmias). Typical examples of toxæmias due to specific agents are furnished by diphtheria, tetanus (lock-jaw), rabies (hydrophobia), and cholera; of septicæmias (or bacteriæmias), by anthrax, typhoid fever, relapsing fever, bubonic plague, influenza (La grippe), malta fever, etc. Besides the diseases here given, there are many others on the border-line between toxæmias and septicæmias, that is to say, the infection may be localized, yet there is a distinct tendency for the infectious agents to invade the blood. Such a disease is pneumonia which, while it is often an infection localized in the lungs, occurs in a form (croupous) in which the pneumococci which cause it are found in the blood in about ninety per cent of the cases. Pulmonary tuberculosis (consumption) is another case in point; the disease may remain localized in the lungs for months and even years, yet the specific bacilli often invade the economy. When they do, the germs are distributed everywhere, and a rapid termination of life results. This form of tuberculosis, called by the profession acute miliary tuberculosis, is well known to the laity under the name of *rapid, galloping, or quick, consumption.*

There is another word in current use in medicine that requires explanation in this place, viz., pyæmia.

By *pyæmia* is understood an infection in which the micro-organisms have established suppurating foci in different parts of the body. Where the several localizations have had their origin in another, single focus, the former are often, although erroneously, spoken of as *metastatic abscesses*.

COMBINED INFECTIONS.

Heretofore the course of a disease due to only one infectious agent has been described, and while we usually, in acute disease, are dealing with a single or uncombined infection, the opposite, mixed or combined infections, are not uncommon. Thus occur together measles and scarlet fever, measles and whooping-cough, scarlet fever and diphtheria, typhoid fever and pneumonia, etc. When two infections occur in the same individual, the symptoms of one disease are likely to be masked or held in abeyance by those of the other, the extent to which this takes place depending upon whether they develop simultaneously or in succession. It also depends upon the nature of the diseases. Thus pneumonia for a number of days may run so typical a course in a person suffering from consumption as to deceive the ablest clinician into believing that only one disease, pneumonia, exists. On the other hand, pneumonia in the alcoholic, in the sufferer from some chronic disorder, e.g., Bright's disease, diabetes, chronic heart disease, or coming on during the course of an acute infection, may be entirely overlooked in spite of the

fact that it is known to be the most frequent direct cause of death.

However, two infections may concurrently run typical courses in the same individual. This happens when scarlet fever and measles develop simultaneously.

SECONDARY INFECTION. When an infectious agent attacks an individual who is already suffering from the attacks of another, we speak of the former as a *secondary infection*. Most secondary infections follow as a result of the diminution in vital resistance consequent upon the first infection. Apart from the ordinary diseases of childhood, there are two notable infections that are very commonly secondary, because they take advantage of any depression in vital resistance that the body has suffered. Their frequency and permiscuity are so well established, that every precaution should always be taken to guard a patient from their attack. Reference is made to tuberculosis and pneumonia. The micro-organisms which cause these two diseases lead all others as secondary invaders of the body, and undoubtedly cause a larger number of deaths than all the diseases combined to which they are secondary. Next to the tubercle bacillus and the pneumococcus in point of frequency as secondary invaders come the common pyogenic or pus-producing bacteria, among which, it should always be remembered, is included the microbe of erysipelas.

INFECTIOUS
DISEASES
ARE SELF-
LIMITING.

An interesting and important phenomenon concerning the infectious diseases is their self-limiting nature. Clinical evidence abundantly corroborates the verity of this statement, since treated or untreated, every infectious disease follows, as it were, a prescribed course. The fact that we divide this course into periods is a significant admission. Except in the case of a few diseases, for which we have specifics, the progress and termination of an infectious disease is determined well-nigh entirely by the reactionary or fighting powers of the body. All living things struggle for existence, which is only another way of saying they resist destruction. The efforts that an organism puts forth to survive is an inherent quality that it can no more control than it can its birth. Therefore, when the body is attacked by an infectious agent, it sustains the attack with such weapons as nature, through heredity, has supplied it for this very purpose; and to this fact, that nature is by far the greatest healer, all physicians and nurses cannot fail to testify.

In the sense in which self-limiting is used when referring to infectious diseases, there is, therefore, implied the meaning that the body delimits the period of disease irrespective of medication. It may seem to aspiring novices in medicine a sad admission, and one that may cause them deep disappointment, yet it cannot be denied that *infectious diseases tend to spontaneous*

recovery. This curious fact is the result of natural phenomena.

ANTIBODIES. Animal experiments have taught us that when certain substances injurious to the well-being of an animal are introduced into the blood, other substances are formed which have the power of neutralizing further injections of the first. Substances manufactured by a living organism in this way are technically called "antibodies;" and the antitoxins of commerce, which are prepared from living animals by inoculating them with the toxins (poisons) of various diseases belong to this class. Antibodies are formed in an animal only when the substances which give rise to them have destroyed a certain amount of tissue, the injured tissues supplying the stimulants which incite to activity the protective functions of the body. When produced, antibodies have no beneficial effects whatsoever upon the tissues already destroyed, but act simply either to neutralize any additional toxin which may yet be circulating, or which may get into the body from the exterior at another time. For these reasons *antitoxins are intrinsically prophylactic*, rather than curative, in as much as if inoculated into a healthy person, they guard against disease by preventing tissue destruction; whereas after infection, they safe-guard the body from greater injury than has already occurred by neutralizing any circulating poison. It is this latter action which has

given them their reputation as curative principles. The production of antibodies represents the reactionary or fighting powers of the body above referred to, and is its natural weapon of defense against disease.

As the result of bacterial infections, distinctly different antibodies are formed which owe their origin to peculiarities in attack of the infecting agents. All bacteria produce disease through their toxins, but because the manner in which the latter are eliminated is not the same for all, there arise differences both in the nature of the protective substances, and the manner in which these substances protect. From the standpoint of disease-production bacteria may be divided in a broad way into two classes, viz., (1) those that attack the body rather through a diffusible poison, which they excrete, than by enormous reproduction; and (2) those in which multiplication is the primary or essential phenomenon, toxin-excretion subsidiary. Bacteria of the first order, through their toxins, give rise to substances which neutralize the latter, that is, antitoxins. Bacteria of the second order, contrariwise, stimulate the body to the formation of substances antagonistic to the bacteria themselves, i.e., antibacterial or bactericidal substances. The protection that antibodies which are bactericidal furnish the body comes through their power of dissolving the bacteria which cause the disease. If immunity against infection is, therefore, contrasted from the standpoint of the etiological agents,

it is either antitoxic or bactericidal.   Technically bactericidal antibodies are known as lysins, or bacteriolysins.

AGGLUTININS.   Antedating and also accompanying the formation of the solvent antibodies (bacteriolysins), there appears in the blood-serum of infected animals and persons other antibodies which have the property of drawing together in groups or clumps the invading bacteria. This phenomenon is called *agglutination*, the substances which excite it, *agglutinins*.

Agglutination, it is commonly accepted, has these two advantages: It is a preliminary stage in the process of immunity (it appears before the bacteriolytic substance); it facilitates the ingestion of the bacteria by the phagocytes (phagocytosis).

Bacteriolysins and agglutinins are specific substances, just as antitoxins are, and therefore act only when brought into relation with such bacteria as call them forth. This knowledge of the specificity of the agglutinins is made use of for the diagnosis of various diseases, especially typhoid fever, the examination for agglutination in the latter disease constituting the well-known Widal reaction.

OPSONINS.   In recovery or immunity from diseases due to the second class of bacteria, i.e., those which attack the body largely through multiplication, another antibody has lately come to the fore which bids fair to overshadow all others in

importance. This is a bactericidal antibody, *opsonin* (I prepare a meal for), that acts in conjunction with the leucocytes to rid the body of invading bacteria.

Opsonin is normally found in the blood, and is increased in immunity. It acts in such a way upon infectious agents that they not only strongly attract the phagocytic leucocytes (positive chemotaxis), but makes them easier of digestion by the latter. It is well that the associated action of opsonin and phagocytosis has been discovered, for bacteriologists had well-nigh despaired of producing bactericidal serums comparable in potency to diphtheria and tetanus antitoxins; the latter, once their toxins were separated from the bacteria, were comparatively easy to prepare; but in the case of those bacteria in which little or no diffusible poison is secreted, the problem of making immune serums presented insurmountable difficulties. This is the reason that in a long list of diseases, such as typhoid fever, bubonic plague, Asiatic cholera, bacillary dysentery, etc., immune serums have not been forthcoming. In opsonin, however, we have a force to work with which, it would appear, can be increased at will, so that if the expectations of workers with opsonins are realized, it will not be long before the immunization and cure of the above mentioned maladies will be in our hands.

It is now almost twenty years since Metchnikoff first called attention to the part that certain white

cells in the blood take in both the prevention and cure of infections. These cells (leucocytes), which he called phagocytes, he believed acted through their power of taking up and digesting bacteria. During all these years since the publication of his theory of phagocytosis Metchnikoff has added many valuable facts corroborating his views. In the light of recently discovered antibody, opsonin, his views on the protective function of the leucocytes are strongly supported, in that data for the first time is supplied which explains the conditions under which phagocytosis is active. Opsonin in the blood-serum of immune animals and persons sensitizes or *opsonizes the infectious agents for easier destruction by the phagocytes.*

Injuries to tissues *per se* produce symptoms, through the disturbance of functions which such loss to the economy entails; but besides these symptoms, there are others, in every infectious disease, which can be definitely ascribed to the production of the defensive substances. The phenomena of disease, therefore, are of a composite character, comprising both the symptoms of injury and those of defense. What part of the symptoms each of these factors causes in a case, it is impossible to determine, but of this we may always feel sure (because the experimental proofs in its favor are conclusive) *no insignificant part of the fever and general malaise in every infectious disease is a necessary adjunct to antibody production.* This fact lends the

strongest support to the view, formerly much debated, that fever is a benign and necessary feature in the class of diseases we are discussing. The modern concep tion of disease takes the position that recovery from an infection is always brought about either through th production of an *immunizing* substance by the body or through the introduction of the same from without. In the body, the period of invasion marks the beginning of antibody formation, which from this time goes on until either recovery or death supervenes. If the former, sufficient antibody is formed to equalize the bacteria or their poisons and prevent further inroads of either upon the tissues; if the latter, the body's defensive mechanism fails to act through weakness, or is over-come by the intensity and massiveness of the virus. The use of antitoxin in disease marks the highest refine-ment of specific medication, in that an immunizing sub-stance is injected into a patient which can be depended upon to counteract or neutralize a definite poisonous (toxic) substance. It aims to take from the patient the burden of producing antibodies, which at best is slow and too often a doubtful quality, by injecting them fully formed and active. These have been pre-pared from some animal which has been subjected to the poison and has recovered. In other words, the immunity forced upon an animal is transferred to the patient. From what has been said concerning the action of antibodies in that they only neutralize their

opposites, it is obvious that the earlier they are used, the more beneficial and potent will they prove in treating disease. It is their late use after great tissue destruction has occurred, that is responsible for failure. In an immune person or animal, antibodies are found throughout the body, in largest quantity in the blood. And it is such *blood-serum*, separated from the other elements of the blood, which is the antitoxin of worldwide fame. Antitoxin (antibody) not only causes no reactions when injected into a patient—the animal from which it was obtained suffered these—but it causes the symptoms due to the body's efforts to produce it on its own account to at once abate. Moreover, if an amount sufficient to neutralize all floating poison is injected, the symptoms due to the action of this are also eliminated. Therefore, there only remain such disturbances as are inevitable when tissues are destroyed and must needs be re-formed. And here again are seen the wonderful workings of nature. In those diseases for which we have specifics, the body-forces play just as important a rôle as the specifics; specifics neutralize the bacteria and their toxins, but they cannot restore to normal the tissues which these agents have injured, nor the functions of organs which they have impaired. Repair is a function of the organism which may be assisted but never supplanted. The part played by the body in this respect in infectious diseases is analogous to that which it plays in surgery. The

surgeon, in operating for the removal of malignant tumors or for some other urgent cause, does his utmost when the dangerous condition for which he operates is removed. But how much would his surgery avail, if the body did not potentially possess amazing powers for repair and reconstruction?*

COMPLICA-
TIONS.
Nearly all complications occurring in the course of diseases, whether they be infectious or non-infectious, are due to infectious agents; and the infectious agents principally at fault are bacteria. The source of the infecting bacteria depends upon circumstance. It may happen that the agent has its habitat upon the individual's integument, or within a cavity of the body leading to the exterior. Thus, pneumonia, occurring as a complication, is caused by the pneumococcus, a micro-organism that almost everyone harbors in his mouth even in health. An instance of contamination from the integument is afforded by furunculosis (boils), a common sequel to various infections during or after convalescence is established.

A second source for bacteria which complicate disease, is found in objects, insects, and persons that come in contact with the patient. Thus wounds soiled with earth are those in which tetanus (lock-jaw), and gaseous gangrene, are liable to develop, because the bacteria which bring about these infections have

* See Chapter on Inflammation.

their home in the ground. The bacteria that produce pus (pyogenic bacteria) are also found in the ground.

Insects, such as flies, bed-bugs, mosquitoes, etc., may be the means of conveying infections. Finally, persons may convey infections. Among persons conveying infections, physicians and nurses are especially dangerous on account of the frequent and close contact that they have with the sick.

The manner in which complications have heretofore been spoken of places them in the same category with secondary infections. This conception of them, however, requires qualification. Besides resulting from invasion of the body by bacteria other than the one producing the original infection, complications may be due to another localization in a distant part of the body of the same organism that produced the original infection. Under such circumstances we do not speak of the complication as a secondary infection, but a *secondary localization or metastasis*. Ignorance of the nature of infectious agents and their migratory tendency led, in the past, to such names as typhoid-pneumonia, a designation which is no longer countenanced because we know that this disease, even when the pneumonia accompanies or initiates typhoid, is typhoid fever with pulmonary localization of the typhoid bacillus in the lungs. Misconceptions concerning their origin were likewise responsible for such names as typho-malarial fever, diphtheritic tonsillitis, etc., hybrids for which there is no excuse.

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TERMINAL INFECTIONS. In the course of all chronic diseases of whatever nature, the sufferer is particularly prone to have his original disease complicated by some infection. Indeed, it is the latter that is the common cause of death. Pneumonia heads the list as a secondary invader, and also in bringing about a termination of life. Next in point of frequency is tuberculosis, and third, are pyogenic infections. When secondary infections, or complications, kill, they are spoken of as *terminal infections*.

EVOLUTION OF DISEASE. Whether the body ever returns to a normal state after having recovered from an infectious disease is still an open question. In the large majority of cases, it apparently does, but we must always remember that time, only, can answer this question in any individual case. Certainly a "spell" of any one of the infectious diseases is not regarded by the profession as interfering with the usual expectancy.* Nevertheless, as the years go by, we are laying more and more stress upon past illness as a factor in present disorders.

For the most part, "diseases that owe their origin to past illness are affections of organs," e.g., Bright's disease, chronic heart disease, locomotor ataxia, the organs being involved in the infectious process at the time of the acute infection, and apparently subsiding

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* Expectancy—the mean or average duration of life of individuals after any specified age.

with it. We say apparently advisedly, because, although the acute inflammation subsides, it too often gives place to a chronic inflammation that extends over years. This chronic inflammatory state is no longer dependent in most cases upon the infectious principle which caused the initial lesion, but is a slow sclerosis, or cicatrization, which consists in a gradual contraction and substitution of the normal tissues of a part by scar tissue. The change is especially prone to occur in organs that have sustained an injury of one kind or another, and is really a vicarious evolution that the tissues are subject to. There is a danger in the new condition that arises both from the contractions, and the loss in organic cellular constituents, since in the one case functions are interfered with, in the other, metabolism* is disturbed. The seriousness of the lesion depends upon the organ in which the original injury was located, and its importance to the vital processes of the body. One or two illustrations will suffice to elucidate our point. A person has typhoid fever and apparently makes a complete recovery. Ten, fifteen or twenty years afterwards he seeks medical advice for shortness of breath and cough. His case is diagnosed as chronic heart disease. Whence came the lesion of his heart valves? When closely questioned, he may remember that the physician who attended

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*Metabolism—chemical change within the body in nutrition and secretion.

him at the time of his fever did remark that there was some slight evidence of cardiac injury. But even this evidence of the connection between his present trouble and the earlier typhoid fever is now no longer necessary; we have learned through experience the connection. Are typhoid bacilli causing the present trouble? Assuredly not! The original cause was an inflammation of the heart valves from the typhoid bacilli, most likely, or some other microbe that gained an entrance into the blood during his attack of typhoid. The lesion of the heart, to all appearances, healed. But a cicatrix remained, that, according to the manner of all cicatrices, continued to contract, until through the disability it produced in the functioning of the heart, gave rise to symptoms. Substantially the same history is obtained in many cases of Bright's disease (chronic nephritis), the antecedent disease being either scarlet fever, measles, diphtheria, or typhoid fever.

We have used the word infectious a number of times, but purposely have avoided using another word, namely, *contagious*, on account of the many loose interpretations that are given it. To us it seems best to speak of a contagion, or a contagious disease, only when the microbe is readily communicable from person to person by mediate or immediate contact. The term should be used as descriptive of a quality of the germ or of a microbic disease. It should not be used synonymously with infectious or infection; in fact, if

the words were synonymous, we would scarcely describe a disease, such as diphtheria, as being both infectious and contagious. A disease may be contagious, or it may be infectious; or it may be both contagious and infectious. Malaria is an infectious disease, but not contagious; scabies (itch) is contagious but not infectious; diphtheria is both contagious and infectious. Diseases exhibit at times, however, marked differences in regard to these characteristics. Sometimes an infectious disease not ordinarily contagious may, in some manner as yet not understood, become contagious. This happens in pneumonia, which under such circumstances partakes of the characteristics of an epidemic disease.

COMMUNI-
CABLE.

Of late years it has seemed best to some authors, on account of the indifferent manner in which the words infectious and contagious have been used in describing a disease, to omit them entirely, and in their stead to speak of these diseases as *communicable*. This seems an excellent innovation because only diseases caused by living things are, strictly speaking, communicable. An objection might be made to the term because it would include parasitic affections, but this cannot for long have any real force; it is difficult at best to draw a nice distinction between many diseases due to parasites and the infectious agents, and we might just as well for good have a word adaptable and usable for both.

CHAPTER II.

BACTERIOLOGY.

Bacteria (sing., bacterium) are low forms of life that are generally conceded to belong to the vegetable kingdom. They resemble the moulds in many ways; in fact, one name for them is fission-moulds, a term derived from the circumstance that multiplication of the individual bacterium takes place by simple division of the whole organism into two parts. They further resemble the moulds in not possessing chlorophyl, the green coloring matter by virtue of which in the presence of sunlight, plants are enabled to decompose carbon dioxide and ammonia, and use their constituents for food.

The absence of chlorophyl in bacteria necessitates some form of proteid as food, whence results the phenomenon of the lowest forms of life consuming the same kinds of food as the higher animals.

Bacteria live chiefly upon the remains of animals and plants, to a lesser extent upon living forms of both kingdoms. But whilst they share a common food with animals, the disintegrations which they work in it

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result in simpler and more important end-products. These consist of the gases absolutely essential to plant life, namely, carbon dioxide (CO_2) and ammonia (NH_3). A third end-product is water (H_2O).

The amount of carbon dioxide produced by animals out of starches and sugars is insignificant in comparison with the needs of the vegetable kingdom, and were there no other source for this important food element, the plant world would either suffer a great deficit or be restricted in its growth. The same is true of nitrogen, another important constituent of plants, and required by them in an easily assimilable form, such as ammonia (NH_3). It is the peculiar office of bacteria to supply plants with the largest amounts of both of these constituents. On this account they are the natural intermediaries between plants and animals in point of food production, playing by far the most important part in the economy of nature. Without bacteria, plant-life would be scanty or entirely wanting; and since the animal kingdom depends upon plants for existence, there would result a world lacking in every form of higher animal life.

ARTS AND INDUSTRIES. The part that bacteria play as scavengers of the earth and providers of food for plant-life, only displays a limited side of their usefulness. In the arts and industries they are as essential to modern economic life as are the ingenious mechanical inventions of man. Many secret

processes now in use in the arts and manufactures are but devices to harness these natural forces. Thus in the manufacture of linen, hemp and sponges, in the butter, cheese, and vinegar industries, in tobacco-curing, etc., bacteria play *the* important rôle.

Curiously, in the popular mind, bacteria Saprophytes. are only associated with disease, and are regarded with abhorrence on that account; yet of the untold hundreds of species, only about forty are known to produce disease in human beings.

Bacteria which are useful to mankind in so many ways belong to the class of organisms known as *obligate saprophytes*, i.e., "an organism that lives upon dead organic matter." Bacteria that produce disease, on the other hand, belong to the parasites and infectious agents, a description of which has already been given in the preceding chapter. However, the ability of a bacterium to live upon dead organic matter does not determine its status from the standpoint of the production of disease. The obligate saprophytes, as their name implies, are restricted to a diet of dead things; but the parasitic bacteria, while preferably parasitic in their habits, may nevertheless lead a saprophytic existence. Such species are known as *facultative* saprophytes. Most of the disease-causing bacteria belong to this class, a factor that has proven of incalculable value in studying them. Indeed, bacteriology dates its rapid progress from the time that pathogenic

bacteria were first grown upon an artificial pabulum in the laboratory. The adaptability of bacteria to various kinds of foods explains the spread of many diseases by foods and water, and also the tenacity that certain diseases display in clinging to a house or to clothing. Almost everywhere there are small amounts of organic matter and moisture, and these microscopic forms of life which we are considering require such infinitesimal amounts of either, that it is possible for them to live where nothing else can.

PATHOGENIC AND NON-PATHOGENIC BACTERIA. Harmful bacteria, that is, those that are capable of producing disease, are called *pathogenic;* harmless varieties, or saprophytes, are called *non-pathogenic*. A pathogenic bacterium, however, cannot always produce disease when it finds lodgment within the body. This special characteristic is extraordinarily variable, appearing and disappearing under a variety of circumstances. Pathogenicity in a bacterium depends upon its power to produce toxins (poisons), a function which is extremely susceptible of loss by exposure to many natural agencies. A pathogenic bacterium that can produce its specific toxins, and therefore bring about disease, is spoken of as *virulent*, one that cannot, as *non-virulent*. For the foregoing reasons we recognize in all pathogenic bacteria both varieties. However, virulence and non-virulence are evanescent qualities, requiring only alterations in environment to be made

to appear and disappear. What the circumstances are that lead to this change will be explained in the third and fourth chapters.

SIZE. In size bacteria are the smallest living things that we can see with the modern microscope. In masses they are readily seen with the unaided eye as moist, slimy, or dry films floating upon the surface of foul fluids or water, or covering decomposing animal or vegetable matter. Some of them produce beautiful colors; others have the peculiar property of producing phosphorescence; still others cause the stench of decomposition.

Bacteria vary in size between five-tenths of a micro-millimeter and twenty to forty micro-millimeters, and as a micro-millimeter is the one-thousandth part of a millimeter (about one-twenty-five-thousandth of an inch), only a vague conception of their minuteness can be formed unless one has had experience in working with microscopic forms of life.

MULTIPLI-CATION. What bacteria lack in size they make up in the astonishing capacity that they possess of rapid multiplication. Each bacterium consists of a single cell only (unicellular), which under favorable circumstances produces countless other cells. This is accomplished by simple division (fission) of the whole cell body. The two individuals formed out of the first one, begin dividing into four before complete separation has taken place;

the four divide into eight, the eight into sixteen, the sixteen into thirty-two. Since it takes only thirty minutes for one cell to divide, it can be computed approximately how many new individuals will be formed in twenty-four hours out of a single bacterium. Conn gives the number as "over 16,500,000 in one day, and about 281,500,000 in two days. In three days, at this rate of multiplication they would produce a mass of bacteria weighing 16,000,000 pounds." However, these figures have no practical significance, and are given merely to convey to the reader some conception of their astonishing rate of multiplication. In nature multiplication is rapid, as may be inferred from the great changes they work, but their activities are limited to their usefulness. Their growth is held in check by the products of their own metabolism (excretory products), by the absence of suitable food, and by natural forces acting upon them as they do upon all creation.

SHAPE. When examined with a microscope, individual bacteria are seen to look like so many dots, dashes, and commas. There are thousands of species of bacteria, yet each species conforms more or less closely to one of these three shapes. According to their form, therefore, they are called, *cocci*, *bacilli*, and *spirilla*, and under these designations all known species are classified.

To the cocci, or micrococci (sing., coccus)—belong the dots or spherical forms.

FIG. 1.—Staphylococci. Streptococci. Diplococci. Tetrads. Sarcinæ. (Williams.)

To the bacilli (sing., bacillus)—the dash-like or rod-shaped bacteria; and to the

FIG. 2.—Bacilli of Various Forms.   (Williams.)

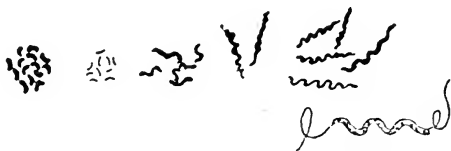Spirilla (sing., spirillum)—the spiral, corkscrew, or comma-shaped forms.

FIG. 3.—Spirilli of Various Forms.   (Williams.)

GROUPING.   Certain of the bacteria exhibit a singular arrangement to each other, when examined on a slide under the microscope, that is peculiar and constant.   This is found in the group micrococcus.   It is due to the manner of multiplication; the bacilli and spirilli multiply by division through

their shortest diameter only, whereas the micrococci, having one diameter the same as another, may divide in any direction. The result of this difference in the manner of dividing is that the relationship of individual bacteria to each other is markedly characteristic, and permits of its use as a distinguishing feature. To distinguish the various micrococci from each other, they are therefore divided into the:

Staphylococci (sing., staphylococcus)—when they are arranged in groups which bear a certain resemblance to a bunch of grapes. Diplococci (sing., diplococcus)— when they are arranged in pairs. Streptococci (sing., streptococcus)—when they are arranged in chains, i.e., attached end to end in lines of longer or shorter lengths.

When cocci show no particular arrangement to each other they are simply spoken of as cocci or micrococci.

The foregoing divisions of the cocci are not complete, since there are other peculiarities of grouping, but those enumerated comprise the principal pathogenic micrococci.

DISTRIBUTION. Bacteria may be said to be universally distributed, being found wherever animals and plants are. They are in the air we breath, and in the water we drink. The surface of the earth is covered with them; in fact the ground is their natural home, which should not surprise us since there organic matter is found in greatest abundance.

Indeed, the source of the bacteria that are in the air and water is the ground. They are carried by the winds with dust, to which they adhere, and by water flowing over the ground. A fact of great importance to be remembered, however, is that *bacteria cannot rise from liquids that contain them* even should a strong current of wind blow over the liquid.

Upon our bodies bacteria are constantly present in large numbers, and in every cavity leading to the exterior, but in the tissues and glands of the healthy person they are never found. The number of bacteria upon the body bears a relationship to the cleanliness of the individual, yet even in the most cleanly they are never absent.

In the same way the number of bacteria in any locality is likewise related to the number of persons, to the density of population, and to the efficiency of the measures practised in the disposal of waste. Any kind of organic matter, whether it be manure heaps, the waste from kitchens, or the dejecta and secretions of man and animals, furnishes appropriate food for these scavengers. The chief interest for us in this wide distribution of bacteria is the relationship of their presence to man and animals, especially in that it draws attention to the danger of contamination of the ground, the water, and food-stuffs from persons and animals suffering from bacterial diseases, and the spread in consequence of disease in this way.

The statement made a few lines above GROUND. that "the natural home for bacteria is the ground" applies to bacteria in general, and as the saprophytes comprise the majority of bacteria, it is to them chiefly that reference is made. Nevertheless, almost any pathogenic bacterium may find in the soil a favorable environment for a longer or shorter period; and even in the event that multiplication cannot take place, the conditions may be such as to preserve its vitality unimpaired. Therefore, as a result of the careless disposal of infectious material and discharges, the soil is often contaminated by micro-organisms of a dangerous character. All pathogenic microbes in the soil are potentially dangerous, yet the possibilities for them doing harm is not the same for each, since it depends upon the species of micro-organism, the physical environments of the soil, and the purposes for which the soil is used. It should always be remembered that when a soil is contaminated with infectious matter, the bacteria present in it will, in dry weather, be carried into the air with dust, and in that way may find their way into our lungs or contaminate our foods. The most widely distributed bacterium in the air, and the most generally dangerous, is the tubercle bacillus. The typhoid bacillus is the most frequent pollutor of wells and streams, although it may become a most dangerous infection in the air if the contamination of the soil is excessive and the

hygienic conditions under which exposed individuals live are especially bad. Just such a condition as described pertained in the great military camps during the Spanish-American war, and the commission, appointed by the Surgeon-General of the army to report on the prevalence of typhoid fever among these troops, ascribed the stupendous morbidity to a few factors chiefly, not the least important of which was the presence of typhoid bacilli in the dust surrounding the camps.

Another way in which germs in the soil may infect persons, and this is true particularly of the typhoid bacillus and the cholera spirillum, is for the microbes to become attached to vegetables grown in the soil, especially if these vegetables are such as are usually consumed raw. However, whilst the majority of pathogenic bacteria in the soil may be regarded as accidental contaminations, there are a few whose natural habitat is the ground. These are the tetanus bacillus, the bacillus of gaseous edema, and the bacillus of malignant edema. In countries where bubonic plague is epidemic, the specific bacillus (*bacillus pestis*) seems to find a favorable environment in the ground.

WATER.   As has been said, water is most frequently polluted by the washings from contaminated soil. The pathogenic bacteria most feared in water or ice are the cholera spirillum and the

typhoid bacillus, on account of the danger of taking them into our intestinal tracts. Because cholera and typhoid fever are most frequently contracted from the drinking of polluted water, they are both spoken of as "*water-borne diseases*." The same micro-organisms are also common contaminators of other foods, the source of the contamination, as a rule, being also water, whether it be used to cleanse utensils, or a contaminated stream in which water-cress or oysters are growing.

AIR. The danger of air as a medium for the distribution of pathogenic bacteria has been much exaggerated, in fact, even the number of all kinds of bacteria in the atmosphere is not as great as is popularly supposed. True! they are practically present everywhere, except at sea many miles from shore, and at great altitudes; yet they are never present in such abundance that "it rains bacteria." At one time the profession believed that the infectious agents of many diseases were carried in the air even considerable distances, a belief no longer held since the importance of the rôle that insects play in the transmission of disease has been recognized.

The most widely distributed pathogenic microorganism in the air is the tubercle bacillus, the cause of consumption, and a large variety of other ailments, such as hip-joint disease, caries of the spine, etc. Over 100,000 persons die annually from consumption

4

alone in United States, and it is estimated that there are over 2,000,000 of people afflicted with this disease in one form or another. All of these sufferers are expectorating billions of tubercle bacilli daily. Many of them are engaged in earning a livelihood, which takes them into offices and homes, the atmosphere of which they contaminate by coughing, sneezing, and expectorating. The atmosphere of our cities is vitiated in the same way, but with less danger to others; for in the open, through the action of sun-light, through heat, dilution, and other physical agencies, the virulence of the bacilli is gradually diminished, and eventually destroyed; finally the bacteria themselves are disintegrated. But in confined spaces, little or no destruction of the bacilli takes place, so that there ensues in a short time an atmosphere ladened with tubercle bacilli, which is highly dangerous to everyone who breathes it. The dangerous condition of such an atmosphere is attested by the frequency of tuberculosis among successive tenants of a house that was the abode, for a period, of a consumptive. In quiet breathing, no tubercle bacilli are projected into the air, but in sneezing and coughing they are; and in the expectoration, estimates of their numbers cannot be placed too high. Thus it is that the tubercle bacilli find their way to the ground, become dry, are ground up with the dust, and with the latter are carried into the air and inhaled. The moral is obvious.

SPECIFIC
AND NON-
SPECIFIC
BACTERIA.

Pathogenic bacteria are either specific or non-specific according as they produce a specific or non-specific disease. In each of these classes are found cocci, bacilli, and spirilla. The following table contains the most important specific and non-specific bacteria:

NON-SPECIFIC BACTERIA.	SPECIFIC BACTERIA.
Micrococci	Micrococci
Staphylococcus pyogenes aureus	Gonococcus
Staphylococcus pyogenes citreus	Diplococcus intracellularis meningitidis
Staphylococcus pyogenes albus	Micrococcus melitensis (Malta fever)
Streptococcus pyogenes (Strep. erysipelatis)	Bacilli
Pneumococcus	B. Anthrax
Tetragenus albus	B. Diphtheria
Tetragenus citreus	B. Glanders
Bacilli	B. Typhoid
Colon group	B. Influenza
Pneumo-bacillus group	B. Tuberculosis
B. Pyocyaneus	B. Leprosy
B. Malignant edema	B. Pestis (bubonic plague)
B. Aërogenes capsulatus	B. Tetanus (lock-jaw)
B. Proteus vulgaris	B. Dysentery

Specific Spirilla
S. Recurrent fever
S. Asiatic cholera
Spirochæta pallida (syphilis)

Spores.   To separate one species of bacteria from another, bacteriologists find it necessary to note with the greatest accuracy the minutest differences in size, shape, arrangement, motility or non-motility, etc., of the individuals of each species; also the appearances of the species when viewed as masses with the naked eye. To do this the bacteria are grown upon various artificially prepared foods, called "culture media," which are valuable in bringing out the peculiarities of the different species. By means of cultures, the various species are also separated one from the other, and the individual characteristics studied. But these distinguishing characteristics can have little interest for anyone unless he works with bacteria in the laboratory. However, one biological characteristic is of very great importance to the practical sanitarian. Reference is made to a resting form of certain of the bacteria that is known as a *spore*. A spore is a glistening oval body into which a bacterium is converted when the environment is unfavorable to its growth. It corresponds to the seeds of a plant. The spore-form of bacteria represents more than a resting stage, however, since by virtue of an investing membrane, they are far more resistant to every destructive agency than the vegetative form. Thus while a temperature of 60° Centigrade (140° F.) kills the vegetative form of almost every bacterium in a few minutes, spores are able to withstand the boiling

point for an hour or longer. Likewise, while a three to five per cent solution of carbolic acid kills most bacteria in half an hour, there are spores that can live for days in the same strength of this acid.

Obviously, therefore, the sporulating bacteria are of very great importance. Happily the number of sporulating bacteria is small, a fact which lessens the difficulty in disinfection, once these species are known. The principal sporogenous (spore-producing) bacteria are the tetanus bacillus, the anthrax bacillus, the bacillus of malignant edema, the bacillus aërogenes capsulatus, and probably, the actinomyces bovis and Maduræ. Fortunately, *not one of these bacteria is the agent of a pestilential, epidemic disease.*

FACTORS NECESSARY TO THE GROWTH OF BACTERIA.

The factors necessary to the growth of pathogenic bacteria are deserving of as much attention as the means devised for destroying them; indeed, all methods which aim at destroying them (disinfection) must needs be faulty unless attention is paid to the conditions under which they flourish. The means are not always at hand to employ those chemical and physical agents that experience has taught may entirely be relied upon. Nor if they are, do the exigencies of the case, on account of the destructive action on fabrics of the most efficient disinfectants, or the bulk of the material to be disinfected, permit of their use. Furthermore, dissemina-

tion of the infectious agents may be so wide-spread as to make actual contact between the usual disinfectants and the infectious agents (an essential condition for satisfactory disinfection) absolutely impossible. Under the several circumstances enumerated, it is self-evident how valuable is the knowledge of the conditions most favorable to the growth of bacteria, since by removing favoring conditions and substituting harmful ones, we can make use of most excellent means for exterminating them. In the discussion which follows, only the conditions favorable to the growth of pathogenic bacteria are treated.

There are five factors principally concerned in the growth of bacteria, any alterations of which may be regarded as distinctly unfavorable; these relate to food, moisture, temperature, light, and relation to oxygen.

FOOD.   Pathogenic bacteria require organic (albuminous) material upon which to feed. It makes little difference what the source, whether vegetable or animal, solid or fluid, fresh or putrid, they are adapted to all kinds. The blood and tissues-juices of the animal body form an especially good medium. Besides being albuminous, the material must have an alkaline reaction. Nearly all bacteria grow best in a slightly alkaline medium, and high alkalinity, or moderate acidity, either stays their growth or destroys them. Hence the strong acids and alkalies are true disinfectants.

MOISTURE. Moisture is essential to the growth of bacteria, in fact, complete drying, except in the case of spores, is followed by death. Thus the spirilla of Asiatic cholera are killed in a few minutes by drying. However, too much reliance cannot be placed on this factor, since an infinitesimal amount of moisture suffices to keep them alive indefinitely.

TEMPERATURE. The most favorable temperature for the growth of pathogenic bacteria is that of our bodies, 98.6° F. (37° C.). They will also readily multiply at lower temperatures if other circumstances permit. Thus the temperature of the ordinary summer day (70° F., 24° C.) is sufficient for rather rapid multiplication. Below this temperature, however, growth becomes slower as the temperature is reduced, and practically ceases at 16° C. (60.8° F.). Above the temperature at which bacteria grow best (optimum temperature), only a few degrees suffice to prevent growth (43° C., 109.4° F.).

OXYGEN. Oxygen is another essential to the growth of bacteria, but there is considerable difference in the manner in which the various species obtain it. The majority grow best when oxygen, as found in the air, is supplied. A majority, however, will not grow in the presence of free oxygen, being compelled to obtain their oxygen from material in which it is in combination with other elements.

According as bacteria grow in the presence or absence of oxygen they are called *aerobes* or *anaerobes* respectively. Most of the aërobic bacteria grow as well without free oxygen as with it, for which reason they are spoken of as *facultative* anaërobes; but the contrary is not true; there are few facultative aërobes.

LIGHT.   All bacteria grow best when protected from light. This statement holds good whether the light be natural or artificial.

These five factors are the chief ones favorable to the growth of bacteria, and to the retention of their native characteristics and qualities. Variations in favoring factors, if not sufficient to destroy them, always tend to modify their functions (prevent growth, etc.), alter their qualities (diminish virulence), and, to a certain extent, produce variations in form. Broadly speaking, variations acting in this way are antiseptics as opposed to disinfectants, which latter are the means used to destroy bacteria. Modifications in favoring factors are all the time in nature acting to reduce the rapidity of multiplication of bacteria, or to prevent it entirely; or by destroying their virulence to curtail their power to do harm. Most excellent use has been made of our knowledge of the growth of bacteria both in ·clinical and preventive medicine. In the treatment of wounds suspected of containing the tetanus bacillus, it is the practice to leave the wound exposed to the air, because we know that the tetanus bacillus will not grow in the

presence of atmospheric air; some physicians go a step farther and advise the spraying of such wounds with oxygen. In the preparation of some of the vaccines, bacteria whose virulence has been reduced or destroyed through subjecting them to unfavorable surroundings are used for the inoculations, a form of vaccination that is now being practised in typhoid fever and bubonic plague. Because cold retards bacterial growth, is one good reason for its use in inflammations. When the urine is alkaline, as is usually the case in inflammations of the bladder (cystitis), every effort is made to change the reaction to acid and thereby make the urine an unfavorable medium for the bacteria which cause the cystitis.

AGENTS HARMFUL TO BACTERIA.

Agents which prevent the growth and activity of bacteria without destroying them are called *antiseptics;* those that destroy them, *disinfectants* or *germicides*. Disinfection has as its object only the destruction of pathogenic microbes. When an object has been rendered free from *all* kinds of micro-organisms and their spores it is said to be *sterile*, and the process by which sterility is brought about is known as *sterilization*.

A *deodorant* is a substance that has the DEODORANT. power to destroy a noxious odor, usually by substituting its own in place of the other. A deodorant may or may not be a disinfectant.

Most of the disinfectants are also deodorants, but the reverse, it is to be remembered, is not true. Thus formalin and carbolic acid are both deodorant and disinfecting substances, whereas musk, a deodorant, has no disinfecting power. Bichloride of mercury, a most powerful disinfectant, is only a deodorant if it is allowed to act for a long period, for which reason it cannot be used for this purpose in the sick-room. All of the disinfectants, when diluted, are also antiseptics. This is important, in as much as in the strengths that many of them are disinfectants, they are injurious to the tissues of the body. Bichloride of mercury 1–50,000 is an efficient antiseptic, yet a strength of 1–1000 is required to kill all bacteria and their spores. The same is true of formalin, which is antiseptic in a solution of 1–50,000, germicidal only in a strength of 3 to 5 per cent. Substances like boracic acid, iodoform, etc., on the other hand, are purely antiseptic, even when employed in concentrated form. Strong solutions of sugar and salt, as used for domestic purposes to preserve various edibles from spoiling, are antiseptic but not germicidal.

INSECTI- CIDES. The prominent place occupied by insects as carriers of disease has given rise to a new interest in substances that will kill them. Interest centers chiefly in the discovery of an efficient substance that will be non-poisonous, yet generally applicable. A substance combining both of

these qualities has not yet been discovered. Substances used to kill insects are called *insecticides*. Nearly all the disinfectants are insecticides; formalin is a notable exception. The most important insecticides are given in a later chapter.

Towards agents which have a harmful action upon them, i.e., either interfere with their growth (antiseptics), or destroy them (disinfectants or germicides), bacteria exhibit distinct differences in resistance—a characteristic which varies with the species. Species which produce spores, are not more resistant to injurious agencies when in the vegetative state, than are the ordinary non-sporulating bacteria. But in the form of spores their power to resist destruction is often marvelous. However, it is not only the sporogenous form which is difficult to deal with; there are a few species which, although they do not produce spores, are nevertheless almost as difficult to kill. The tubercle bacillus is one of these, and it is due to this fact, in conjunction with the universal prevalence of tuberculosis, that the tubercle bacillus has a wider distribution in nature than any other specific pathogenic micro-organism.

The most wide-spread destruction of bacteria is brought about through natural forces. Where actual destruction is not accomplished, the same influences so modify their characteristics as to render them inert. It is in this way that pathogenic bacteria are robbed of

their virulence and made harmless. Undoubtedly the limitation of infectious diseases, which otherwise would be impossible of control, is brought about in this manner. Nature's means are simple, yet all-pervading, wherefore she accomplishes more than the combined efforts of men. And her forces are effective, and always at our disposal, so that it behooves us to learn her ways and profitably make use of her bounty. The forces which nature employs are chiefly light, drying, dilution, cold, and symbiosis (association).

LIGHT.   Among the natural agencies destructive to bacteria, sun-light occupies the first place.

It is by far the greatest destroyer of germ-life. Few microbes can live in direct sun-light many hours, the pathogenics being especially susceptible to its influence. Its destructive influence is exerted whether the bacteria are in a dry state, or in a liquid. Moreover, it acts upon them whether the solution is clear, or is as foul as sewage. For example, only twelve hours' exposure to direct sun-light is required to render sewage free from bacteria, i.e., sterile. It also kills spores, if the exposure is longer.

DRYNESS.   Sun-light has the power of acting directly upon bacteria in liquids, as has just been stated. But it has another action equally important which enhances its disinfecting powers to a point scarcely equaled by any gaseous disinfectant, namely, drying. With the exception of spores, com-

plete drying practically kills all pathogenic bacteria. This statement, however, is only true where *complete drying* is accomplished, a matter that we can never be sure of unless we control the situation as is done in the laboratory.

OZONE. Besides sun-light and drying, ozone (nascent oxygen) also takes part in the destruction of bacterial life. But as this substance as formed in nature occurs only in small quantities, its importance in this respect is difficult to measure. More ozone is found in the country than in cities, a factor that undoubtedly contributes to the greater healthfulness of rural surroundings.

COLD. Cold, we have already learned, is unfavorable to the growth of bacteria. At the freezing temperature ($32°$ F., $0°$ C.) most bacteria succumb. However, some species exhibit considerable resistance to freezing. This is true of the micro-organisms of typhoid fever (typhoid bacillus) and Asiatic cholera (spirillum of Asiatic cholera), epidemics of both of which diseases have been traced to ice as the source of the infection.

DILUTION. Dilution, or the diminution by dilution, of the number of bacteria per volume of material in which they are contained, is also accomplished by nature. How great a benefit this is to man will be better explained in a succeeding

chapter. Here reference is only made to the fact that, as the number of bacteria which get into the body plays a highly important part in the production of disease, adequate dilution of infectious agents may make them innocuous. Hence one value of dilution is evident. Another effect of dilution is to separate the individual microbes, and thereby permit of closer and more thorough contact with them of the natural destructive agencies. In practical disinfection dilution of the infectious material is for this reason always practised. If the material is semi-solid it is diluted with a disinfectant in which it is soluble; or it is broken up, if not soluble, to permit of closer contact of the disinfectant with as much of the material as is possible. If liquids are to be disinfected, either a liquid disinfectant is used, or one that is soluble in the solution to be disinfected. In any case, sufficient time (one hour for the disinfectants in common use) is given for penetration.

SYMBIOSIS (association). By symbiosis is understood the living together of different species of organisms in the same medium.

It further implies that they are mutually helpful and beneficial. Among bacteria in nature a struggle for existence is constantly taking place, which in conjunction with other natural forces serves to keep their numbers within limits. Of the two classes of bacteria, parasites and saprophytes, the saprophytes are the more numerous and by far the hardier, so that when they are

growing side by side with pathogenics, the latter get less food and suffer from the excretory products of the former. Hence in the process of putrefaction, as of sewage or of diseased carcasses, *self-purification* is largely brought about by the saprophytes crowding out the weaker pathogenics.

BACTERICIDAL POWER OF BODY-JUICES. Another natural force tending to the destruction of bacterial life is the *bactericidal** action of the body-juices of all living things. The number of bacteria which rest upon our bodies, and even get into the interior, is incalculable, yet very few do us harm on account of this property of living matter. This protective power of the body when displayed against a disease is called *immunity*.

HEAT. The destructive action of heat upon bacteria is so well known that it often comes as a surprise that, in disinfection, more confidence should be placed in chemicals. As a matter of fact, there is no more efficient disinfectant than heat if properly applied. It is also the cheapest. With few exceptions, bacteria are killed in a few minutes at a temperature considerably below the boiling point of water; and at the boiling point at once. Yet it is a common practice for both physicians and nurses to put a family to considerable expense for chemical disinfectants in a case of typhoid fever, for example, when heat

* Bacteria destroying.

applied directly, or several times the quantity of boiling water added to the material to be disinfected (stools, for instance), and the mixture allowed to stand an hour, is as trustworthy a practice as the use of any disinfectant; and far more so than many chemicals whose virtues are highly extolled in newspapers and medical journals.

We have seen that although the optimum temperature for the growth of pathogenic bacteria is that of the body (98.6° F.), they will multiply at a much lower temperature. Above the temperature of the body, however, the limit is small, since growth ceases at 109.4° F. (43° C.). At 140° F. (60° C.) the vegetative forms of practically all bacteria are destroyed if applied for ten minutes, and the time required to destroy them diminishes as the temperature rises. At 212° F. (100° C.) as we have stated, they are killed immediately. The tubercle bacillus, although only occurring in a vegetative form (i.e., does not form spores), is an exception in that boiling for five minutes is required to destroy it.

CHEMICALS. There are a large number of substances which have a detrimental effect upon bacteria, some merely inhibiting their growth (antiseptics), others destroying them (disinfectants). Their number is too great to enumerate. Those that interest us because they are useful in rendering infectious matter harmless will be given in a later chapter.

Cleanliness is an efficient weapon to
Cleanliness. employ against bacteria. Too much can-
not be said in its favor. Through it we
can dispose of the most essential factor in the growth
of bacteria, namely, organic matter. Where organic
matter does not exist, bacteria cannot live and multiply.

Material of any kind, containing bacteria, is said
to be *septic;* when free from bacteria, *aseptic.* In
practical work, e.g., surgery, objects and persons are
rendered bacteria-free either through the use of antisep-
tics and disinfectants, or by mechanical cleansing with
soap and water. The two methods are distinguished
as the antiseptic, and aseptic methods respectively.

CHAPTER III.

PHENOMENA OF INFECTION.

There are two view-points from which the production of an infectious disease must always be studied, viz., (1) the infecting micro-organism, and (2) the state of the body at the time the infection occurs. Apart from injuries and direct poisonings, there are no independent causes of disease. When we say an infectious disease is due to this or that micro-organism, we are making a statement which expresses only a fraction of the true sequence of events, since unassisted, infectious agents probably never, under the ordinary conditions of life, bring about disease. To be sure, their presence in an infectious process is indispensable, yet the mere fact of their presence counts for naught unless the body has been prepared, so to speak, for their invasion. Furthermore, even in the event that the body be in a most favorable condition for infection, there are several conditions which micro-organisms must fulfill before they can exercise their specific functions. For the foregoing reasons, therefore, an infectious disease is the result of the co-existence of a chain of fortuitous phenom-

ena which concern the body on the one hand, and the infectious agents on the other. To illustrate: We say that the pneumococcus is the cause of pneumonia because this particular micro-organism is found in the characteristic expectoration during life, and in the lungs after death. Unquestionably, it is a necessary factor in the disease; but is it the sole factor? We have only to examine the facts in the case to discover that it is not. In the first place, practically everyone, even in health, harbors the pneumococcus in his mouth. In the second place, pneumonia in robust individuals invariably follows either fatigue and exposure to inclement weather, or exposure and over-indulgence in intoxicants; often a combination of all three factors precedes the onset. In the less robust, e.g., those suffering from chronic ailments—(a condition in which susceptibility to pneumonia is especially marked) it is the pre-existing sub-normal state of the health which permits the micro-organisms to invade the deeper air-passages and produce the disease. Again: It is a matter of common observation that of a number of individuals exposed to the same infectious disease not all are attacked, and that in those susceptible the disease presents extraordinary variations as regards its mildness or severity. If the microbe were the sole factor concerned, all exposed individuals would be attacked, and all attacked would suffer to the same degree; a thing which everyone knows never happens. More-

over, a person may resist the action of a pathogenic agent at one time and fall victim to it at another.

INFECTIOUS AGENTS IN DISEASE.

From the view-point of infectious agents there are five conditions to be fulfilled before they can provoke disease:

(1) They must be present in sufficient numbers.

(2) They must reach (what is for them) their portal of entry.

(3) They must be virulent.

(4) In the case of certain pathogenic agents, disease can result only when the agent is accompanied by one or more other micro-organisms, or when accompanied by a foreign body.

(5) If a disease is communicated exclusively by an insect, obviously the presence of that insect is an essential condition.

NUMBER.   Contrary to a wide-spread belief, there is no disease which a single infectious agent, acting alone, can produce; that is to say, one micro-organism of a certain species, however virulent it may be, is incapable of provoking disease. Experimentally it has been found that even in animals very susceptible to them, it takes large numbers of a particular micro-organism to bring about characteristic results.   In diseases occurring among persons we have no way of determining the number of germs that pri-

marily enter the body, yet a wealth of facts gleaned through experiments upon animals leads us to conclude their numbers must be large. Clinical observations also furnish some data in support of this view. In cases where long and tedious operations are performed, a wound is often exposed to the air for hours without ill effects following. Certainly no one believes that during the time of exposure and manipulation bacteria do not soil the wound. On the contrary, we know they do; but the reason harm only occasionally results from those that enter is attributed to the fact that either they are present in insufficient numbers and are of low virulence, or the vital forces of the patient are sufficient to destroy them. Similar observations are made by physicians in the repair of injuries in which either aseptic or antiseptic precautions are utterly impossible. Thus in the practice of mid-wifery, for example, although such unfortunate surroundings are quite common, cases of puerperal fever (child-bed fever) are so infrequent as to excite comment. Indeed, puerperal fever occurs occasionally under conditions in which the surroundings are ideal, probably through the fulfillment of the third condition above given, viz., extraordinary virulence of the germs.

PORTAL OF ENTRY. A singular peculiarity of pathogenic microorganisms is that in order to provoke disease, they must find lodgment in or upon that portion of the body which offers the

least resistance to their attack.   The tissues of the body
vary in susceptibility to microbic invasion, the differ-
ence having a relation to the species of organism.   Thus
there are certain bacteria which can exert a specific
action only when they gain entrance into the intestinal
tract; to this class belong the typhoid bacillus and the
spirillum of Asiatic cholera.   There are bacteria, on the
other hand, such as the tetanus bacillus, the gas bacillus,
and the common bacteria of suppurations, which may
be swallowed with impunity, in fact often are, their
characteristic effects being produced only by entrance
into a wound of the skin or a mucous membrane.
Similarly, the diphtheria bacillus has no effect upon the
unbroken skin, nor upon the mucous membranes of the
stomach or intestines, although, in the disease, countless
numbers are swallowed; it selects per force the mucous
membranes of the nose, the pharynx, and the posterior
nares chiefly, less often those of the conjunctiva and
the vulva.

The channel of entry, therefore, occupies an impor-
tant position when the subject of a micro-organism's
pathogenicity is under consideration, since upon it will
depend the result of the presence of a pathogenic agent
whether the latter does or does not satisfy every other
condition necessary for its specific action.

VIRULENCE.   The real power of every species of micro-
organism which produces disease lies in
its ability to secrete one or more toxins.

When it has this power it is said to be virulent. In another chapter the remarkable inconstancy of the toxicity of micro-organisms has been considered (vide p. 41). That virulence in bacteria is an essential phenomenon in disease-production has been abundantly confirmed by the finding, in their propitious channels of entry, of various pathogenic micro-organisms in perfectly healthy individuals, the organisms so found being commonly non-virulent varieties.

All pathogenic bacteria vary in respect to virulence, and, as has been explained in a previous chapter, are on this account divided into those which are virulent and those which are non-virulent. However, it should be remembered that non-virulent bacteria are not without danger to individuals who carry them, and to other persons to whom they may be conveyed, since they may acquire virulence either before or after transference, and provoke disease.

MICROBIC ASSOCIATION (symbiosis). Microbic association in disease is of common occurrence, the resulting mixed infection usually being severer than an unmixed one. Thus in diphtheria, the diphtheria bacillus is often associated with the streptococcus pyogenes or the staphylococcus pyogenes aureus; the typhoid bacillus with the *bacillus coli communis*, a common inhabitant of the intestinal tract. There are some bacteria, however, which cannot exercise their power without the co-operation of another

bacterium. To this class belongs the tetanus bacillus, which, being an obligate anaërobic bacillus (cannot grow in the presence of free oxygen), is compelled to work with another germ that, by absorbing the oxygen, makes the surroundings favorable for its growth. This bacillus also works mischief chiefly when accompanied by a foreign body, as for example a sliver, powder-grain, etc., or where there has been much laceration of tissues. The same thing is true of the *bacillus aerogenes capsulatus*.

CONVEYANCE BY INSECTS. There are a few infectious diseases, such as malarial fever, yellow fever, and filariasis, in which the infectious agents are exclusively conveyed by insects. All such diseases are due to animal parasites, which for complete development require two hosts, man and an insect. Each host nourishes the parasite during one phase of its growth only, so that in order to reach maturity the latter must pass consecutively from one host to another. Furthermore, since parasites are restricted to especial hosts, the presence of an appropriate host for each one is imperative if they are to be perpetuated. Therefore it follows that the communicability of a disease by an insect is only possible in the event of the presence of that particular variety of insect. So circumscribed is the world of parasitism! For instance, yellow fever is conveyed by only one genus of mosquito (stegomyia

fasciata), malarial fever by a few varieties of another (anopheles), etc.

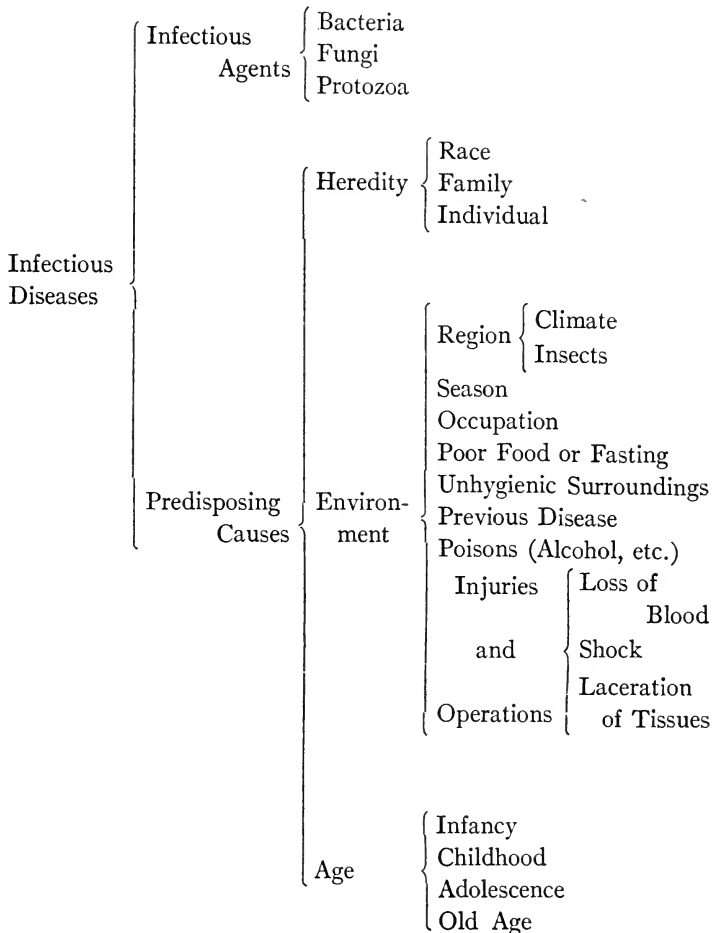## THE BODY IN RELATION TO INFECTIONS.

We have just considered the exacting conditions which an infectious agent must fulfill to provoke disease. The fulfillment of these conditions, however, only meets the requirements in so far as the micro-organism is concerned, and therefore presents but one side of the problem; the other side, the position that the body occupies in relation to infections, is equally important, and it is to this phase of the question that we now turn. A few lines above, this statement was made, "it is a matter of common observation that, of a number of individuals exposed to the same infectious disease, not all are attacked; and in those susceptible, the disease presents extraordinary variations as regards its mildness or severity. If the microbe were the sole factor concerned, all exposed persons would be attacked, and all taking the disease would suffer to the same degree; a thing which everyone knows never happens. Moreover, a person may resist the action of a pathogenic agent at one time, and fall victim to it at another." The question that naturally presents itself is, what brings about such radical differences in the vulnerability of individuals to infectious agents? That it is not always consequent upon modifications in the agents, we know from observations upon patients, and experiments upon

animals.   To account for it, there is obviously some subtle difference in the vital processes of different individuals, and in the same person at different times.

Every healthy person is by nature endowed with the means of combating disease, but his natural defenses, while they may be strengthened, may also be weakened by those forces and influences which surround him. Nor before the tribunal, disease, are all men born equal, since progenitors may transmit to their offspring constitutions defective in defensive force.   Furthermore, during the constructive (infancy and childhood) and degenerative (old age) periods of life the protective forces are, on the other hand, weakened through immaturity, on the other, by the fact that they are declining with age.   Therefore, to *environment*, *heredity*, *and age*, must we look for an explanation of any imperfection in our natural resistance to disease.

Predisposition.   The absence of resistance to disease, i.e., susceptibility, has been given the comprehensive title *predisposition*, and we characterize as *predisposing* every influence or cause which tends to weaken the vital forces and therefore predisposes to disease.   In every infection such causes always play an important rôle, usually more important than the infectious agents, a fact to which too little heed is given in the hurly-burly of life.   The attitude of the world in this respect is not unlike its greater faith in the curative powers of drugs, than in a disciplinary regulation

of its habits. If we should symbolize infectious agents as a spider, and humanity as a fly, then the web would

Infectious Diseases

Infectious Agents
- Bacteria
- Fungi
- Protozoa

Predisposing Causes

Heredity
- Race
- Family
- Individual

Environment
- Region
  - Climate
  - Insects
- Season
- Occupation
- Poor Food or Fasting
- Unhygienic Surroundings
- Previous Disease
- Poisons (Alcohol, etc.)
- Injuries and Operations
  - Loss of Blood
  - Shock
  - Laceration of Tissues

Age
- Infancy
- Childhood
- Adolescence
- Old Age

represent predisposing causes, for only when the fly is entangled in the web does the spider attack its victim.

It will be observed that this conception of disease does not undervalue the part that infectious agents play as *direct* or *exciting* causes of disease, but it further recognizes fully the preponderating influence of those *accessory*, *auxiliary*, or *predisposing* causes without which the animate agents cannot act.   The analytical chart here shown aims to elucidate graphically this view.   To be sure, all of the diverse elements represented are not operative at the same time in any infectious disease; but one or several always are, and these act in combination with the infectious agents.

HEREDITY.   Referring to the chart, it will be seen that there are three sub-divisions to heredity, viz., race, family, and individual.

RACE.   Our knowledge of race as influencing infection is of comparatively recent date. This knowledge, besides having an important bearing upon etiology, is of historical interest in explaining the errors of judgment which in the past led to great crimes.   In many notable epidemics the Jews were singled out for persecution, because they escaped the prevailing scourge, their immunity being ascribed to a special knowledge of the epidemic disease.   During cholera epidemics, the relationship to drinking-water which was recognized, they were accused of poisoning wells, and the brutal ferocity of insensate mob-violence

was visited upon them. But the dispassionate reasoning of scientific investigation has acquitted them of those charges by explaining their insusceptibility to infection as a peculiarity of the Hebrew race. Thus, by far, fewer Jews are victims of pulmonary tuberculosis than Gentiles, and Asiatic cholera is so rare among them as to lead some authors to doubt that it ever occurs. Furthermore, they suffer less severely from other infections, and less from animal parasites, than other races. However, it must be confessed that in the case of the Jews (and in that of any other race, for that matter), racial characteristics do not explain entirely the absence of predisposition. We should err greatly did we fail to take into account a race's habits and customs. For instance, other things equal, the Jews are better housed, eat more wholesome food, are more cleanly in their habits, take better care of their children, and are less given to intoxicants, than their Gentile neighbors; while all of them are still influenced more or less by the Mosaic laws. Their standard of life, if adopted by any people, would tend to strengthen its vital resistance and, in some at least, would lead to the establishment of the antithesis of predisposition, namely, *immunity*.

Another factor which exercises its influence upon a race's susceptibility, or immunity, is the length of time it has been in contact with a disease. The first conflict of a race with an infectious disease often proves

highly disastrous, as witness the terrible ravages of measles among the natives of the Faroe Islands in 1846, when out of 7,782 people, 6,000 were attacked; and also the invasion of the Fiji Islands in 1875 by the same malady, during which 40,000 of its 150,000 inhabitants died.   Nor is it necessary to cite examples of distant peoples; in our own country we have an object lesson in the Negro and the Indian.   The Negro is three times as susceptible to tuberculosis as the white inhabitants; and the North American Indian has been well-nigh exterminated by this "great white plague."   Generally speaking, the longer the contact of a race with an infectious disease, the less is its predisposition to it. Tuberculosis well illustrates this point in the respect that the most ancient race, the Jews, suffers least from it; other races, in inverse ratio to their antiquity. Diminution in susceptibility through contact is probably brought about by large numbers of individuals in successive generations surviving an infection, and transmitting to succeeding generations their own individual resistance, together with that acquired by passing through an attack of the disease.   Yet after every factor, such as surroundings, food, contact with a disease, etc., has been considered, there is still wanting an explanation of the fact that when two races live side by side, under precisely similar circumstances, the one suffers from an infectious disease to a greater extent than does the other.   Upon no other grounds than

racial peculiarity, can this be explained. Animals also exhibit the same peculiarity in susceptibility to disease. Among cattle, Jerseys are more susceptible to tuberculosis than other breeds. Dogs are practically immune to it, a fact which probably explains the high position dog-fat holds among the ignorant as a remedy for tuberculosis. At a laboratory at which the writer once worked, and where many dogs were used for experimental purposes, the janitor sold large quantities of the fat to a local charlatan who in turn disposed of it as a specific for consumption. It must not be supposed, however, that racial immunity, such as is frequently the case with individuals, is ever perfect. There are always families and individuals whose immunity is diminished by marriage and environment, and the whole race is subject to those diseases which are incidental to age.

FAMILY. As the family partakes of the characteristics of the race, family predisposition is subject to the same general rules as described for races, with the exception, that marriage between members of different races by blending the vital forces may either increase or decrease the power to combat disease. A similar result follows the union of persons of the same family; and the great danger of a summation of highly susceptible strains has led, in many states, to the wise enactment of a law against consanguineous marriages. An extension of this law

to include inebriates and consumptives has many arguments in its favor.

INDIVIDUAL. From the view-point of the body, individual predisposition is the principal factor in the spread of infectious diseases. With few exceptions it is operative in every case, so that the study of the various conditions which lead to it involves considerations of the highest importance to physicians, nurses, and sanitarians generally. Individual predisposition may either be *inherited* or *acquired*. If inherited, it is seldom to any particular infection but to all. We no longer believe in an inherited predisposition to a special disease, as was formerly the case with tuberculosis, but rather in the inheritance of an especially susceptible state of the body-tissues which predisposes to all manner of infections. Not alone are the children of the consumptive markedly prone to consumption but also the children of all parents who at the time of conception were either in an impoverished state of health from disease, or whose vital resistance was depressed by alcohol, drugs, or by deprivations of one kind or another. The reason that the consumptive's offspring has fewer chances of escaping tuberculosis than the child of the non-tuberculous, is because the atmosphere of its home is, in the majority of cases, through ignorance, vitiated by the germs of its parent's malady. Besides a general predisposition such as we have been discussing, a predisposition to local disorders

is also recognized. This relates to a susceptibility of certain organs or tissues as a result of other concurrent infections. Thus, rheumatism predisposes to infections of the heart; diabetes, to suppurative inflammations (carbuncles) and gangrene of the skin and subcutaneous tissues; enlarged tonsils and adenoids to colds, tonsillitis, and probably diphtheria.

ENVIRON-
MENT.
Under environment is included all those external influences by which man is surrounded which, by exercising a deleterious influence upon health, predispose him to disease. Among such influences are region, season, occupation, food, unhygienic surroundings, previous disease, poisons, injuries, etc.

REGION.
Locality may act as a predisposing cause in many ways, all of which may be grouped under two heads, viz., (1) climate, and (2) physical conditions.

CLIMATE.
Climatic conditions, as is well known, differ widely in various parts of the world, from which arise for the most part great differences in plant and animal life. Moreover, practically everywhere, there are seasonal variations more or less pronounced, which have their corresponding influence upon all living things. In tropical and subtropical countries where a high mean temperature and a maximum amount of moisture predominate, the luxuriance of the foliage and the multiformity of animal

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life never cease to excite the admiration and wonder of the traveler. While from the temperate zone, in a direction away from the equator, vegetable and animal life grows less and less abundant and flourishes for a briefer period of each year, as we approach the frigid zones. These diversities in climate have given origin to forms of life peculiar to themselves, and attention is directed to this most obvious phenomenon *because similar influences play their part in the production of disease the world over*. The living agents of disease are either animal or vegetable, and are therefore subject to the same physical laws as govern forms higher than they. Just as there are plants and animals indigenous to the several regions, so do we find pathogenic agents in one region that are not encountered in another. Likewise, as many plants native to temperate zones outgrow in size and color all semblance to the original when cultivated under tropical atmospheric conditions, so do certain diseases common in temperate latitudes, where they are relatively mild, assume in the tropics a virulence that makes of them a terrible scourge. But here the simile of flora and fauna, and disease, ends. Tropical plants, unless carefully nurtured, do not prosper when transplanted in temperate climates; whereas tropical diseases do, if circumstances are the least propitious, when they are introduced. The microscopic agents of disease are less sensitive in some respects to physical agents than plants, and moreover

are capable of ready adaptation to new environment. Conquest, improved methods of travel, and shorter routes, have brought the tropics to the very doors of Western nations, with the result, that in the great commercial benefits accruing from easy intercourse, there has come a menace in the guise of disease. Here and there tropical diseases have already been introduced, and while the number of such instances is insignificant, and they have been successfully combated, it has excited alarm. And well might it! Europe has a number of times been over-run with Oriental plagues. Up to the present these problems have been dealt with chiefly in those countries where such diseases prevail, but who can say when from a single imported case a herculean task in sanitation and preventive medicine will not confront some nation? In temperate latitudes, tropical heat is seasonable for one or more months each year, a time during which the way is open for the spread of an exotic disease. This danger the nations are cognizant of, and special commissions are investigating such diseases in those regions where they are endemic. Whenever anything is discovered which bids fair to prove valuable as a preventive, it is at once given a practical test, since it is obvious that the only real safe-guard the peoples of temperate climates have against foreign diseases, is to stamp them out in their home-country. All of the nations have likewise founded schools of "Tropical Medicine," where the etiology and sanitary

control of tropical diseases are studied, and where the same is taught to physicians and nurses whose duty it may be, at some time, to cope with them.

An ever present danger to both natives and foreigners in tropical countries is intestinal diseases. The climatic conditions predispose to congestion of the abdominal viscera, which predisposes the latter to infections. Even in the absence of infectious agents, chronic engorgement may give rise to lasting injury in one or another organ. The liver is the organ commonly affected in this way, a chronic enlargement with resulting torpidity in functioning, frequently making the unfortunate sufferer an invalid for life. Lay writers, particularly English authors, have long recognized this affliction, and very properly held it responsible for many disagreeable traits of character. The enlarged liver of the retired East Indian official so often referred to by Thackeray, is therefore not a mere creation of the novelist's, but founded upon fact. But the chief interest for us in the congestion of the viscera due to intense heat, is in the fact that it predisposes to a host of infectious and animal intestinal parasites with which the tropics abound. Nearly all of these agents get into the body through the drinking-water, or from eating raw fruits and vegetables, and the infectious disorders which they excite are either of the intestines, or the intestines and liver. The commonest infectious disease of the tropics is dysentery, of which there are two

varieties, namely, (1) bacillary dysentery, due to a bacillus (*bacillus dysenteriæ*, Shiga), the other, (2) amœbic dysentery, due to the *amœba dysenteriæ*, an animal organism. Next in importance to these infections are various disorders resulting from animal parasites. By exercising great caution in the matter of food and drink, one may avoid the infectious and parasitic intestinal disorders, if he cannot those solely dependent upon climate. From the latter, too, it is not impossible to escape, if one abstains entirely from alcoholics and other excesses which tend to increase the amount of blood in organs already overfilled, and if occasional visits to cooler climates be made. The most rigid adherence to the laws of health, combined with such as are especially adapted to a hot country, must be followed. These measures if carried out, and provided the individual is free from disease in the beginning, will ensure the same average health in a tropical as in a temperate country.

PHYSICAL CONDITIONS. The degree of warmth, the amount of moisture, and the physical conditions of a country, all have a bearing upon predisposition, because they supply an essential environment for the perpetuation of forms of life which either cause disease, or transmit it. Besides the vegetable micro-organisms, bacteria and moulds, there are other microscopic and larger forms of life belonging to the animal kingdom which produce disease. Among

these, protozoa, the lowest form of animal life, are of prime importance. Then there are flukes, worms, and insects. Of the pathogenic protozoa known, nearly all depend upon suctorial insects for transmission from one person to another. The rôle of insects in the production of disease is large, forming a highly important branch of medicine; and it is destined to become much larger. Two kinds of transmission of pathogenic micro-organisms by living agents are recognized, (1) in which the insect is merely an accidental carrier of the micro-organism; (2) in which the insect acts as host for the micro-organism during one phase of its life-cycle. Where the insect is an accidental carrier of the microbe, the surface of its body, or its excrement, has been contaminated by feeding upon infectious material. Under such circumstances a disease is transmitted either through the soiling of a wound, or through the contamination of an article of diet. While living upon the insect no increase in numbers of the pathogenic agent takes place. Bacterial (and possibly a few protozoan) diseases are frequently transmitted in this way. In a previous chapter the wide-spread prevalence of typhoid fever in the United States military camps during the Spanish-American war was mentioned to illustrate the transmission of bacteria by flies. Besides flies, ants, bed-bugs, fleas, and ticks, may also accidentally carry bacteria, and besides typhoid fever, insects are believed

to transmit at times other bacterial diseases such as Asiatic cholera, bubonic plague, leprosy, tuberculosis, small-pox, etc.

But where an insect acts as host for a pathogenic agent, an entirely different condition is presented. Here, while the contamination of the host is accidental in so far as the latter is concerned, it is a necessary sequence on the part of the pathogenic agent. Agents of this class are alternately parasitic upon human beings and insects. Upon each host a supplementary development begun in one is continued in the other. In no other way can growth from egg to adult (life-cycle) be accomplished. In addition to this remarkable provision, each agent, through the workings of a fixed biological law, is peculiarly restricted to especial hosts without which it cannot develop. It follows, therefore, that the propagation of diseases by insect-hosts is absolutely contingent upon the presence of that particular species of insect which is the agent's natural host.

Hosts may belong to the class of suctorial (biting) insects, or to such as are likely to get into our food or drink. One instance of a disease due to a protozoan which is transmitted by an insect (mosquito), is furnished by malarial fever; another, by sleeping-sickness (trypanosomiasis), of which the African stinging fly *glossina* is the host.

Among larger organisms which themselves produce pathological conditions are insects, flukes, worms, etc.

Most of these have as yet a circumscribed distribution, so that the diseases which they cause are limited to certain regions.   Examples of such diseases are parasitic hæmoptysis (pulmonary distomiasis), which is found almost exclusively in China, Japan, and Formosa; bilharziosis (endemic or Egyptian hæmaturia), prevailing particularly in Egypt, North Africa, Arabia and Persia; hook-worm disease (ankylostomiasis, uncinariasis), common in Porto Rica, Southern United States, the Philippine Islands and Egypt; guinea-worm disease (dracontiasis), occurring principally in Africa, East Indies, and Panama.   These examples suffice to show the relationship between insects and disease on the one hand, and regions and insects, upon the other.   It is because the physical characteristics in so large a measure determine the insect and animal life of a country that we include them among the predisposing causes of disease.

In tropical and sub-tropical countries many more diseases are due to animal infectious agents, and animal parasites, than in temperate latitudes, and larger numbers of both agents are transmitted by insects. This fact again emphasizes the danger to the peoples of temperate climates in that either pathogenic parasites themselves, or their insect-hosts, may be imported during the period of greatest heat and moisture, find the conditions propitious for multiplication, and sow their virus promiscuously.   Moreover, a few may become

acclimated and survive the cold of the winter months, breed fresh generations the following summer, and in this way establish a new endemic focus for the diseases which they carry.

A good example of an insect which acts as host for an infectious animal micro-organism, and one which depends for existence upon the physical conditions of a country, is found in the species of mosquito (anopheles) which transmits malarial fever. As the anopheles only breeds in shallow puddles of water or slowly moving streams, it is manifest that well-drained regions are likely to be free from malaria, while those presenting an opposite condition are favorable to its introduction. This same species of mosquito neither breeds nor bites when the temperature is below 68 Fahrenheit, a fact which explains the constant presence of ague in tropical climates. High altitudes, and mountainous regions, because they do not present the physical conditions necessary for the multiplication of the anopheles, are free from malarial fever; but the same is not true for yellow fever, which is transmitted by another species of mosquito, the *stegomyia fasciata*. This species breeds in rain-spouts, cisterns, and small collections of water about a household. Given a favoring climate, therefore, where the practice of storing water about dwellings prevails, there is no reason why this pestiferous insect cannot become domesticated in regions that are now outside the yellow fever zones. An

illustration of the altitude the stegomyia may reach is furnished by the history of yellow fever in Mexico, as reported by the U. S. Public Health and Marine-Hospital Service. A commission from this Service, called Working Party No. 1, found this mosquito at an altitude of 4200 feet above the sea level, an ascent which they ascribe to a shortening of the time-distance between coast and interior by the building of a railroad.

SEASON.   That season and disease are related phenomena has already been included in our discussion of climate. It only remains to illustrate the relationship. Yellow fever is a disease of tropical countries, and of sub-tropical regions during the warm months; typhoid fever occurs everywhere chiefly in the autumn and early winter months.

The effect of season upon disease is strikingly shown if we compare the two extremes of the year, summer and winter. The heated term is characterized by diseases affecting the intestinal tract, the cold and blustry months, by affections of the respiratory organs and joints.

FASTING, POOR FOOD, ETC.   Fasting, poor food, unhygienic surroundings, etc., are potential factors in the production of infectious diseases. They all conduce to a low state of the vital forces; and an impoverished body falls an easy prey to the pathogenic agents. Nor are the effects of other agencies grouped in our chart under environ-

ment dissimilar in their action. Previous disease, alcoholism, injuries, and operations, all portend the same end, viz., a lessening of the natural resistance. The blood and its cells contain the largest amounts of those active principles which combat disease, and when it wastes, as it does in every disorder, this function is depressed or suspended. Besides being "thinned" by disease, the blood suffers impoverishment through poisons (e.g., alcohol, lead); through the absence of either sufficient or nourishing food; through unhygienic surroundings, and by actual loss in volume and cellular constituents in hæmorrhages consequent upon operations and injuries, and also blood sucking parasites. In unhygienic surroundings perhaps the most potent evil is the absence of pure air (oxygen) in sufficient amounts to meet the normal needs of the body.

Typhoid fever furnishes a remarkable example of the predisposing influence of a disease. After an attack of typhoid, a person is particularly prone to diseases of the biliary passages, such as inflammation of the gall-bladder (cholecystitis) and gall-stone formation (cholelithiasis). Predisposition is brought about in the following way: During the fever, typhoid bacilli find their way into the gall-bladder, where they are liable to remain for months and even years, and besides constituting a nidus there for the formation of gall-stones, may also at any time give rise to either a catarrhal or suppurative inflammation of this organ.

OCCUPATION.   That occupation has a pronounced influence upon longevity is well illustrated by the comparative mortality table appended.

Comparative mortality of men twenty-five to sixty-five years of age, in different occupations, 1881 to 1883 (Ogle):

OCCUPATION.	COMPARATIVE MORTALITY.
Clergymen, priests and ministers	100
Lawyers	152
Medical men	202
Gardeners	108
Farmers	114
Commercial clerks	179
Innkeepers, liquor dealers	274
Inn, hotel service	396
Brewers	245
Butchers	211
Bakers	172
Tailors	189
Book-binders	210
Builders, masons, brick-layers	174
Carpenters	147
Plumbers, painters, glaziers	216
Blacksmiths	175
Cotton manufacture	196
Cutler, scissor maker	229
File makers	300
Glass workers	214
Earthen-ware workers	314
Coal miners	160
Stone, slate quarries	202
Street hawkers	338

The laws of nearly all the States take cognizance of the dangerous character of certain occupations by specifying the safe-guards under which work of this nature is to be done, and penalizing disobedience. They further recognize that many occupations are not in themselves so injurious to health as the unhygienic condition of the surroundings, the crowded states of the work-shops, and the long hours imposed. Sweat-shops exhibit in the highest degree the evils just referred to.

The predisposing influence of an occupation may be exerted locally upon some organ, as the lung, or upon the body generally. Thus pulmonary tuberculosis is of frequent occurrence in persons whose occupations are carried on in an atmosphere of dust peculiar to their trades, e.g., stone-cutters, file-grinders, cutlers, cut-glass grinders, etc., a danger which can be diminished by placing suction hoods above the field of work. Not all dust, however, is equally harmful, a difference demonstrated in the case of coal miners who, while breathing in a dust-laden atmosphere day after day for years, are not markedly predisposed to tuberculosis. Another example of the predisposing influence of occu-pation upon an organ is found in seamstresses, who, on account of the attitude assumed while working, are predisposed to ulcer of the stomach.

Occupations which create a general predisposition are those in which the worker is either subjected to the

action of poisons, or in which the tension of the work is a severe strain upon the nervous system. Some poisons *per se* produce pathological states, e.g., lead, arsenic, mercury, etc. These also tend to the production of an impoverished state of the blood (anæmia), constipation, etc., abnormalities which we already have called attention to as paving the way for infections. Occupations involving severe strains disturb the nervous system, which in turn affects the nutrition and functions of every part of the body.

In Ogle's table illustrating the comparative mortality in the various occupations, innkeepers and liquor dealers are seen to head the list in point of frequency. This is not because there is anything especially injurious in the occupation, but because the occupation usually leads to excessive indulgence in intoxicants. So well recognized is this association of alcoholism with the handling or sale of liquors, that life insurance companies universally regard individuals of this class as bad "risks" and refuse to insure their lives.

Age.   The incidence of age and disease is well established. There are disorders of infancy, of childhood, of adolescence, and of old age. Middle life also has its afflictions in the way of special diseases, but as we are limited to infectious diseases, and they are not associated to any marked extent with this period, the affections peculiar to it will not be discussed.

INFANCY.

The young infant is remarkable in its comparative freedom from the infectious diseases of childhood. During late fœtal life the unborn child may suffer from a large number of infectious diseases which perchance attack the mother, and many instances are on record of infants being born with typhoid fever and small-pox; indeed the fœtus has been known to survive an attack of small-pox and be born with a scarred face, a circumstance which attended the birth of the great obstetrician, Mauriceau. To measles and scarlet fever, and even such a virulent infection as yellow fever, the infant up to the sixth month and often longer, is practically immune; the same is true of typhoid fever and other exanthemata; yet to small-pox it is highly susceptible.

From one infection in particular should the newborn be protected, namely, erysipelas of the umbilical cord, a disease, as we have seen, which has great danger in it for the mother also. Another infection for which the umbilical cord is a portal of entry is tetanus, an accident fortunately not often encountered. It occurs, however, sporadically in a few localities where the bacilli are numerous in the ground, and then among the poorest and least cleanly of the people.

At the time of birth, if the mother is suffering from gonorrhœa, the infant is liable to three localizations of this disease, viz., in the mouth and conjunctivæ of the eyes, and in females, in the vulva also. Gonorrhœal

conjunctivitis (ophthalmia neonatorum) is a very serious infection, and requires prompt treatment if the sight is to be saved. From sixty to seventy per cent of all blindness in the world has been caused by it. Happily, loss of sight may be guarded against by dropping one drop of a 1 per cent solution of nitrate of silver between the parted lids of each eye, at birth, in all infants born of mothers who are not above suspicion; indeed, nearly all maternity hospitals and out-patient departments make this a routine procedure.

Gonorrhœa of the vulva is also a serious affection. Very few vaginal discharges in children have any other origin. The disease is not only important because it may affect the child in after years, but also because it may cause death from peritonitis by extension of the infection to the peritoneal cavity.

CHILDHOOD. To the end of the second year diarrhœa in summer, and respiratory infections in winter, are the principal diseases. From the second year to puberty is the period of greatest susceptibility to scarlet fever, measles, chicken-pox, mumps, whooping-cough, and diphtheria. These years embrace the period of childhood, and on account of the preponderance of the above mentioned diseases during this time the latter are called the "diseases of childhood." Diseases peculiar to children exhibit such variations from the same or other diseases seen in later

life as to have given rise to *specialists*. The specialty is called *pædiatrics*.

Besides the general infectious diseases, children are more predisposed to infections of the lymphatic glands and bones than adults. The glands most frequently affected are those of the neck (cervical); and the infectious agents are either the tubercle bacillus, or the common pus cocci. Inflammation of bone, osteomyelitis, is also a frequent affliction of childhood. The thigh and lower leg are the most likely sites for infectious foci. In this affection the tubercle bacillus, and the pyogenic cocci, are again the common cause. The unsightly deformity of hunchback (Pott's disease), and the lesser evil, hip-joint disease, are also examples of the localization of the tubercle bacillus in bone.

Adoles-
cence.
Young adults still exhibit some susceptibility to the diseases of childhood, but in a much lessened degree. However, at this period susceptibility is principally shown towards two wide-spread diseases, pulmonary tuberculosis and typhoid fever. Predisposition to the former is almost entirely the result of heredity and environment; to the latter it appears that age is the most important contributing factor.

Old Age.
Pneumonia is the commonest infectious disease of the declining years of life, and the principal cause of death. In men, prostatic enlargement frequently interferes with the

voiding of urine, a condition which itself predisposes to inflammation of the bladder (cystitis). Often there is such obstruction that "catheter-life"* is necessarily resorted to, with the result that infection sooner or later occurs. This *per se* is not immediately dangerous to life, although the intermittent pyrexia (fever), and the continuous discharge of pus, sap the patient's strength. Subsequently symptoms of toxæmia develop either through extension of the inflammation to the kidneys or from absorption, or from both causes. Death finally takes place from an intensification of the toxæmia, or from bacteriæmia. Pulmonary tuberculosis is also encountered in old persons, and may also be a cause of death. Besides these affections, there are practically no others to which a person beyond sixty years is predisposed. Occasionally measles attacks a patriarch, and sometimes typhoid fever, but such instances are exceptional.

* The condition in which a catheter is always employed when the bladder is to be emptied.

CHAPTER IV.

INFLAMMATION.

The changes which take place in a tissue when injured, and all those changes which follow as a consequence of the injury, constitute inflammation. In previous chapters emphasis was laid on the fact that the body resents injury and is quick to battle against any agent which tends to do it harm; also, that it possesses remarkable reconstructive ability when destruction of tissues has occurred. Both the defensive and reconstructive powers of the body are due to what was termed its "defensive mechanism," a function that has grown to its present proportions through the operation of natural laws which govern survival and development.

We have seen that recovery from infectious diseases is due to the neutralization of the toxic products of bacteria, or solution of the bacteria themselves by substances (antibodies) which are formed within the body. The action of antibodies, however, is limited either to the neutralization of toxins or bacteria, since they neither repair injured tissues nor replace those destroyed. In simple injuries from mechanical and physical causes,

and also in some inflicted by many chemical and animate ones, antibodies are not created, because the toxins which stimulate their production are wanting. In such instances the reactions excited at the site of the injury suffice to counteract the action of the damaging agent and repair the tissues affected. But when infectious agents, and also certain poisons e. g., snake venom, produce injuries, then both antibodies and local defensive phenomena are brought into action. Hence the defensive mechanism, it will be observed, has a dual action; one, to produce antibodies; the other, to repair tissues injured and destroyed. The process of repair is characterized by entirely different phenomena than those of antibody formation, albeit both often arise from the same source, viz., injury to cells. This difference is illustrated by the fact that while, on the one hand, the formation of antibodies is conducted by cells situated at a distance from the lesion, repair, on the other, is a process which involves the lesion itself and neighboring cells. For the process of repair the name *inflammation* is used, and under it are included all immediate and subsequent changes in a tissue or organ that has sustained an injury.

If it were our purpose to treat inflammations exhaustively, we should have to take into consideration the various agents which produce bodily injuries, and every tissue and organ susceptible of injury; also such local and general conditions of the body as influence

the process in one way or another. Furthermore, because pathogenic agents differ so greatly in the reactions which they excite, and different tissues respond so variously to the same or different pathogenic agents, we would be led into a description of every form of inflammation, both acute and chronic—a study that would not end until almost the whole domain of pathological anatomy would have been explored. But such is not our purpose. There are certain fundamental phenomena which characterize every inflammation which, while they represent the primary reactions to injury, are, at the same time, preliminary to repair. These we propose to explain. Besides, the evolution of inflammations in general presents special features which permit us to point out the protean* character of the process without committing us to a lengthy discussion.

CARDINAL SYMPTOMS OF INFLAMMATION.   Four so-called cardinal symptoms of inflammation are commonly recognized, viz., heat, redness, swelling and pain. To these a fifth is added by some authors, interference with function. The phenomena which underlie these symptoms are as follows: Redness is due to a dilatation of the adjacent blood vessels; swelling, to the increased calibre of the blood-vessels, and to blood-serum and blood-cells which have passed out from the walls of the former into the sur-

*Assuming different forms.

rounding tissues. Pain is due to tension and pressure exerted on neighboring nerve-endings; heat to the fact that there is both an increased amount of blood in the part, and because metabolism is locally quickened. Since the nutrition of a part is obviously disturbed by inflammatory phenomena, there is no need to dwell on the associated disturbance of function. Dilatation of blood-vessels, exudation of serum, and migration of blood-cells, are therefore the body's initial response to injury (local reactionary phenomena), and are present in the beginning of inflammation.

The earliest stage of inflammation, *congestion*, is not considered beyond the borderland of health, indeed it is the normal physiological state of a tissue or organ when active. When, however, serum has escaped into the tissues (effusion), this boundary has been passed, although the part may return to normal without loss of substance through absorption of the exudate by the veins and lymphatics. An exudation is protective to the body from infection both through its germicidal powers and by dilution of toxins.

LEUCOCYTES. Among the early phenomena of inflammation is the escape of cellular elements from the blood-vessels. These cells consist of both red blood-corpuscles and larger colorless cells, called leucocytes. There are many varieties of leucocytes in the blood, but probably only two or three of these have a share in the inflammatory process.

Those concerned are capable of independent move-
ment, and make their exit from the capillaries by
insinuating themselves between the cells which line
the capillary walls. The fenestra which they open
close again, but not quickly enough to prevent the escape
of a few of the red cells. Once beyond the vessel-
walls the movements of leucocytes are determined by a
mysterious force exerted by the infectious agents.
This force (chemotaxis) either attracts (positive chemo-
taxis), or repells them (negative chemotaxis).

　　　　　Negative chemotaxis, however, is only
CHEMOTAXIS. active so long as the agent is present, for
　　　　　on the cessation of the agent's action, or
its elimination, leucocytes return and take up their
specific functions. In inflammatory conditions the
leucocytes have several offices to perform; they carry
off the debris of injured cells, and any foreign matter
introduced when the injury was sustained; they also
destroy by digestion invading bacteria; a third office
is to take part in the formation of new tissue. In the
last instance they are actually converted into grow-
ing tissue cells. Metchnikoff, a distinguished bacteriol-
ogist, who is our greatest authority on the place of
leucocytes in inflammation, contends that they are also
largely concerned in the production of immunizing
substances (antibodies). Be this as it may, it is plain
that the leucocytes are exceedingly valuable factors
in inflammations.

PHAGOCY-
TOSIS.
The most important function of leucocytes in local and general inflammations is to destroy bacteria, an action which is designated *phagocytic*, the function itself, *phagocytosis*.

LEUCOCY-
TOSIS.
In almost every inflammatory condition of the body the number of leucocytes in the blood is increased. Normally, there are about 6000 of all kinds to the cubic centimeter, but 50,000 to 60,000 are not unusual in inflammations. When present in numbers above 7000, a *leucocytosis* is said to be present. The explanation of this increase of leucocytes in the blood is found in the large numbers required at inflammatory foci. In the discharge from an abscess, for example, there are present 4 to 5 millions per cubic centimeter. The additions made to the normal number of leucocytes in the blood are due to the stimulated activity of the blood-forming (hematopoietic) organs which, as occasions arise, verily surcharge the blood with them. Whence comes the stimulus? Obviously from absorption of a product formed at the site of the injury. Leucocytosis is therefore another phenomenon which should impress upon us the deep-seated reactions occasioned by every injury, whether the latter gives rise to general symptoms or not, and how far parts of the defensive mechanism are placed from the injury. In injuries due to mechanical and physical agents, when not complicated by invading bacteria, the succeeding inflam-

mations follow an orderly progress to repair; exudations are absorbed, dead cells and their debris are removed by the phagocytes and connective tissue cells, and either connective tissue cells or cells peculiar to the organ or tissues involved take the place of those removed. But most inflammations are not of this nature, being caused or complicated by bacteria and their toxic products. The first effect of the latter is the same in all cases, viz., to excite the cardinal phenomena of inflammation; from this point, however, the further progress and termination of the process is determined by the interaction of three forces:

1. The nature and intensity of the invading agent.
2. The tissue or tissues in which the bacteria are localized.

3. The local and general resistance of the individual.
Thus the same micro-organism (streptococcus pyogenes) which on a mucous membrane can produce a false membrane, may in the subcutaneous tissues give rise to an abscess, or to gangrene; or if the local resistance is not sufficient, will invade the blood and cause a bacteriæmia. Another bacterium, the tubercle bacillus, produces usually tumor-like growths in tissues, but it often causes rapid necrosis, and not infrequently pus.

Here it may be well to direct attention to the fact that in infectious diseases the inflammatory process is not confined to a single locality or organ; but since

either the bacteria or their toxins, or both, are disseminated throughout the body, such parts are affected as are susceptible to their action, and in these inflammations are excited.

If early subsidence of the primary phenomena of an inflammation does not take place, necrobiosis of greater or lesser degree follows: in those instances where some cell destruction was the starting point for the phenomena, there is extension of the necrobiotic area. Viewed from the stand-point of tendency, inflammations are either destructive or constructive, that is to say, some exhibit an immediate tendency to disorganization of tissues, other to organization. However, to say that the tendency of an inflammation is destructive does not contradict what has been said of the general purpose of inflammations, viz., defense and repair.

SUPPURATION. A microbe enters a wound in the skin, or by way of the blood, the tissues of some internal organ. Through multiplication and the excretion of toxins a focus of necrosis is established. Coincidentally with the formation of this focus the cardinal signs of inflammation have made their appearance, and so performed their part that the necrobiotic area is circumscribed by a wall of leucocytes which act as a barrier against deeper invasions. Beyond the leucocytic wall, connective tissue cells are in active process of proliferation preparatory to encroaching upon the necrotic area as it is

eliminated. Suppose the invading microbe belongs to a species which causes suppuration. The next stage in this form of inflammation would then be lique-faction of the dead cells by ferments, and rupture of the fluid contents through the skin. Gradual enlarge-ment of the opening often permits a *"core"* of dead tissue not yet liquefied to be extruded. The material escaping from such a lesion is pus, and consists chiefly of large numbers of leucocytes suspended in serum and liquefied tissues. In this discharge are also eliminated bacteria and toxins. Leucocytes give pus its creamy consistency and yellow color. The dead tissue having thus been gotten rid of, healing goes on through growth of connective tissue cells and contraction (cicatrization). The above is a description of the formation and course of an abscess.

Suppuration under natural conditions is practically always due to bacteria—a single exception among animal infectious agents being the amœba of dysen-tery, which is known to cause abscess of the liver. There are a number of bacteria which cause suppura-tion; some habitually, some specifically, and others acci-dentally. The common members of these three groups are as follows:

1. PYOGENIC BACTERIA.

Staphylococcus pyogenes aureus.
Staphylococcus pyogenes citreus.
Staphylococcus pyogenes albus.

Streptococcus pyogenes.
Micrococcus tetragenus.
Bacillus pyocyaneus.

2. SPECIFIC PYOGENIC BACTERIA.

Diplococcus intracellularis meningitidis.
Gonococcus.
Bacillus of glanders.
Bacillus of bubonic plague.

3. ACCIDENTAL PYOGENIC BACTERIA.

Bacillus of anthrax.
Bacillus of tuberculosis.
Bacillus of influenza.
Bacillus of typhoid fever.

Suppuration is one example of a destructive inflammation; gangrene is another.

When the inflammatory phenomena are not too intense, the connective tissue cells tend at once to organize about the area of injury and repair it. They form what are called infectious nodules. This type of inflammation is represented by syphilis and tuberculosis, and illustrates the antithesis of suppurative inflammations in its immediate tendency to repair.

CHAPTER V.

ANIMAL PARASITES.

Man is host for numerous animal parasites both large and small. A parasite, we have seen, is "an organism which lives upon another organism called the host." Parasites may live permanently upon their hosts, or be only temporary inhabitants. They may have their habitat upon the exterior of our body, when they are called *ecto-parasites;* or within it (*endo-parasites*). All human ecto-parasites are either mites (arachnida), or true insects; all endo-parasites belong to the protozoa, trematoda, cestoda, or nematoda.

By temporary parasite is implied an organism which seeks the human body for a single meal only, and passes for the next to a new host. To this class belongs mosquitoes, bed-bugs, ticks, etc. By permanent parasite is understood an organism which, when it finds lodgment upon or within the body, remains there until dislodged either by accident, through the instrumentality of drugs, or because the host is no longer a suitable pabulum either for further development or for a continued existence. Death of the host, of course, terminates the status, parasitism. Most human endo-

parasites are remarkable for the complicated and unusual manner by which they attain maturity; indeed, it is owing to this unusual evolution that they produce pathological states. Nearly all require for their complete growth at least two hosts, man and some other creature, in each of which complementary stages of development take place. They may also have a stage of growth in water or in the ground. Taken together, the progressive development of a parasite from egg to adult is called its cycle. Parasites which require two hosts to complete their cycle may pass these in hosts which are biologically allied, as for example, the beef and pork tape-worms, whose hosts other than man are respectively implied in their names. Often, however, the dissimilitude in hosts is truly remarkable, and causes us to marvel at the ingenuity which unraveled their cycles. Thus, the parasites of malaria, yellow fever, and filariasis, have each a stage of development in particular mosquitoes; the guinea-worm, in a water-flea; the schistoma hæmatobium, in a special species of snail. The examples given above illustrate a curious phenomenon in regard to parasites and hosts to which there are few exceptions, viz., that each parasite is restricted to hosts which enable it to complete its cycle,

Note:—For a fuller description than is given here of animal parasites, well illustrated, the general reader is referred to Tyson's "Practice of Medicine," 4th ed.; or numerous articles in Woods' "Ref. Handbook of the Medical Sciences," last ed.

and that development cannot take place in insects and animals which do not have this relationship to the parasites. One illustration will suffice; no other mosquito besides the genus stegomyia fasciata can harbor or convey yellow fever, and none besides the genus anopheles, malaria. In the stomach of other varieties of mosquitoes than anopheles the *plasmodia malariæ* are digested.

PROTOZOA.

The smallest forms of animal life parasitic upon man belong to the protozoa. The latter constitute that class of organisms the individuals of which are composed of only a single cell. Like bacteria, all parasitic protozoa are microscopic in size. Their structure, however, is far more complex, and their life-cycle is bizarre in the extreme. Thus, some are known to develop partly in water and partly in a host; others entirely within the bodies of two or more hosts.

Those which have part of a cycle in water, and the other in man, usually gain entrance into the body in the drinking-water.

Examples of this class are found in the amœba of dysentery and the *coccidium hominis*. The last mentioned is probably the cause, also, of that peculiar tumor known as epithelioma contagiosum. On the other hand, in the case of such varieties as never reach the external world, but spend their whole existence in various special hosts, these are usually conveyed to

man by one of their hosts which itself is also a human parasite. An instance of the latter is found in the malarial plasmodium, which is inoculated by the anopheles mosquito.

The principal human protozoan parasites are the *amœba dysenteriæ*, the *trypanosoma gambiense*, the protozoan of Dum-Dum fever, and the *plasmodium malariæ* (three varieties).

AMŒBA DYSENTERIÆ. This parasite is the cause of an acute and chronic dysentery principally prevalent in Egypt, India, and tropical countries generally, although it also occasions a large proportion of the cases of dysentery in the United States.

FIG. 4.—Amœba Coli. (Greene after Braun.)
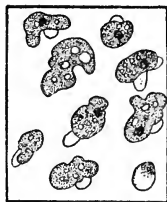
The site of its activity is the large intestine, the mucous membrane of which it erodes and undermines to an extent seen in no other malady. The organism gains entrance into the body in the drinking-water and through polluted vegetables which are eaten raw. There is a special tendency to abscess of the liver in dysentery of amœbic origin, and perforation of the abscess through the diaphragm into the right lung is a not uncommon event. In appearance this amœba is not unlike the white corpuscles of the blood. Harmless amœbæ, however, also occur normally in the stools and must be differentiated from the pathogenic *amœba histolytica*.

Trypanosomiasis, or the infestment of the
blood with flagellated protozoa, trypano-
somes, is common among many varieties
of animals, viz., fish, birds, horses, cattle,
etc. In some it is productive of disease,
in others not. Different varieties of trypanosomes,
probably, are the cause respectively of the disease of
horses and cattle in India and the Philippine Islands
known as *surra*, and of the tsetse-fly disease or *nagana*
of South Africa. In man the parasite is associated
with the dreadful African "Sleeping-sickness," and is
transmitted by the stinging fly *glossina*.

TRYPANOSOMA
GAMBIENSE.

Dum-Dum fever, or Tropical Spleno-
megaly, is a protozoan infection prevalent
among the natives of India, Assam, Ceylon,
China and Egypt. The parasite, Donovan-
Leishman bodies, has been found widely distributed
in the body. The manner of transmission is unknown.

DUM-DUM
FEVER.

Protozoa which increase their numbers
by the production of spores or seeds are
called sporozoa. When sporozoa live at
the expense of the red blood-cells of an
animal they are especially distinguished by the signifi-
cant name *hæmosporidia.* To the latter class belongs
the plasmodium of malaria. The plasmodium malariæ
(Laveran), of which there are three varieties, lives and
develops within, and at the cost of, the colored cor-
puscles of the blood. When first seen it appears as a

PLASMODIUM
MALARIÆ.

8

Description of Fig. 5.

Life history of malaria parasite, *plasmodium*. 1, Sporozoite, introduced by mosquito into human blood, the sporozoite becomes a schizont; 2, young schizont; 3, young schizont in a red blood-corpuscle; 4, full-grown schizont; 5, nuclear division; 6, spores, or merozoites, from a single mother-cell; 7, young macrogamete (female), from a merozoite, and situated in a red blood-corpuscle; 7a, young microgametoblast (male); 8, full-grown macrogamete; 8a, full-grown microgametoblast; 9, mature macrogamete; 9a, mature microgametoblast; 9b, resting cell, bearing six flagellate microgametes (male); 10, fertilization of a macrogamete by a motile microgamete; the macrogamete next becomes an oökinete; 11, oökinete, or wandering cell, which penetrates into the wall of the stomach of the mosquito; 12, oökinete in the outer region of the wall of the stomach, i. e., next to the body cavity; 13, young oöcyst, derived from the oökinete; 14, oöcyst, containing sporoblasts, which develop into sporozoites; 15, older oöcyst; 16, mature oöcysts, containing sporozoites; 17, transverse section of salivary gland of an *Anopheles* mosquito, showing sporozoites of the malaria parasite in the gland cells surrounding the central canal.

1–6, illustrate *schizogony* (asexual production of spores); 7–16, *sporogony* (sexual production of spores).

(Folsom—After Grassi and Leuckart, by permission of Dr. Carl Chun.)
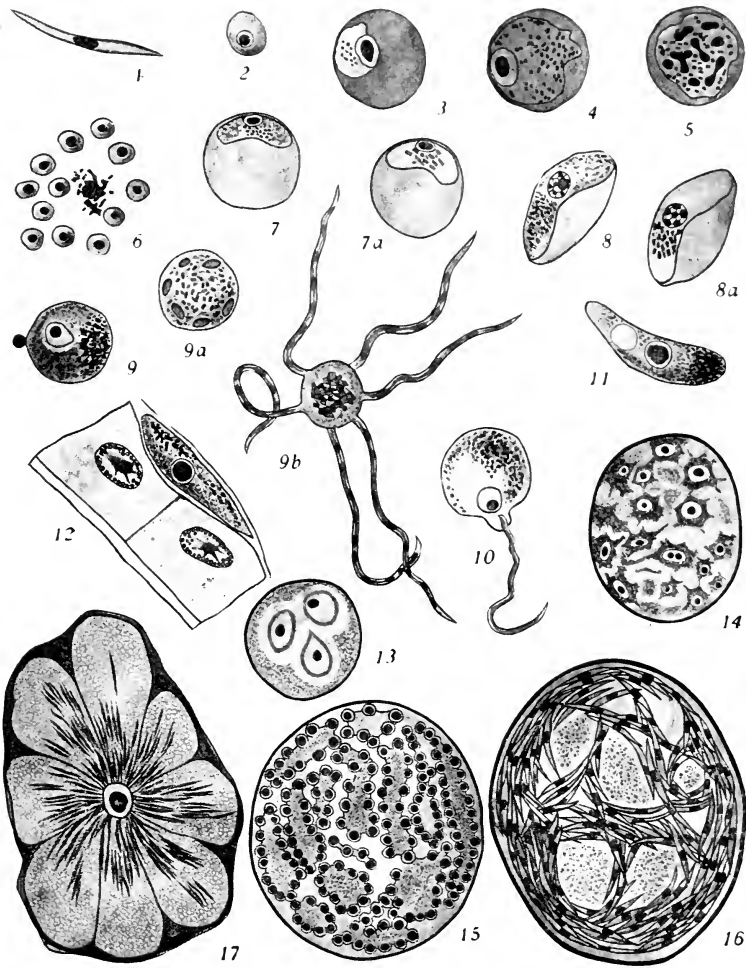
Fig. 5

small irregular colorless body within the red blood-cell. This body increases gradually in size until it quite fills the cell. As it grows, pigment-granules appear, which at first are peripherally placed, but later collect in a clump in the center of the parasite. At this stage the parasite has matured, and its whole body splits up into spores, or new young parasites which, upon rupture of the red blood-corpuscle, are set free in the blood and attach themselves to fresh cells. In an infected person large numbers of plasmodia appear to reach maturity and sporulate about the same time, and it has been found that the chills and fever correspond with this division of the parasites.

In *tertian malarial fever*, the plasmodium attains maturity in forty-eight hours, in *quartan fever*, seventy-two hours, facts which seem to explain the regularity of the chills in these two forms of ague. In *æstivo-autumnal fever* another special variety of parasite is concerned which attains maturity in from twenty-four to forty-eight hours, in consequence of which the course of this form of ague is irregular.

During the course of all the malarias there are also formed in the blood oval, spherical, or crescentic bodies, some of which are flagellated, others non-flagellated. These are sexual elements of the parasites, the flagellated forms constituting the males, the non-flagellated, the females. Union of these in the blood, however, for some unknown reason, does not take place,

but in the stomach of different species of mosquitoes of the genus anopheles, which suck up the malarial parasites when biting. In the mosquito's stomach, coalescence (copulation) of the sexual elements occurs and a new organism is formed. The new parasite in turn forms other organisms in large numbers, which pass from the mosquito's stomach to its body-cavity and thence collect in its salivary glands; from this situation they find their way into the blood of man again when the insect bites. The forms thus inoculated give rise to malaria.

It has been definitely proven that malarial fever can be conveyed in only one way, viz., through the bite of a mosquito which harbors the plasmodium, and that only species of the genus anopheles are capable of acting as host to this parasite. Clinically the pathological states resulting from invasion of the body by the protozoan parasites above described are not unlike those of an infectious disease; indeed, we regard them as belonging to the latter class, and would therefore include the agents which cause them among the infectious agents. They are placed among the parasites *here* simply for convenience of description.

NEMATODES.

FILARIA MEDINENSIS (Dracunculus medinensis). Or guinea-worm, is a round worm which develops in the subcutaneous tissues. Only the female is known. The worm is taken into the stomach probably through

drinkingwater containing small aquatic crustaceans (*Cyclops quadricornis*) which themselves harbor the embryos. The embryos penetrate the intestinal wall, reach the subcutaneous tissues, and there attain full development. The seat of election is the lower extremities, particularly about the heels, yet the parasite has been found in other parts of the body. It is said that the worm can be felt beneath the skin "like a bundle of strings." When the worm is mature it breaks through the integument, forming at first a little vesicle, later a small discharging ulcer, and from the bottom of the latter the head sometimes protrudes. Embryos are
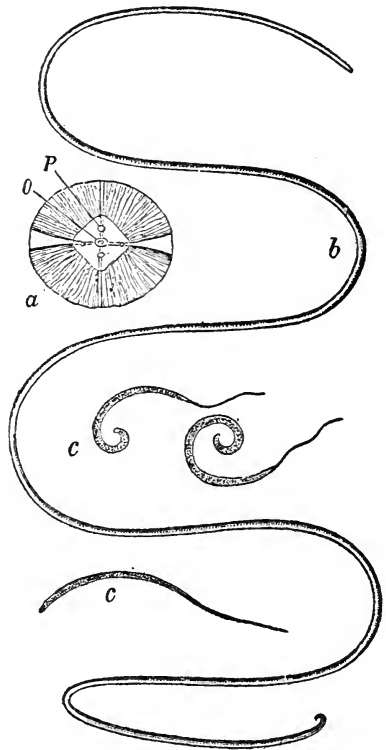
FIG. 6.—*Filaria medinensis; a*, anterior extremity; *O*, mouth; *P*, papillæ; *b*, female, reduced to less than half normal adult size; *c*, larvæ, enlarged. (Braun, after Claus.)

discharged through the opening in the skin, more particularly when water is applied. After getting rid of

her larvæ the worm leaves her host spontaneously.   The embryos find their way into water, often, probably, when the host is bathing, and as has been said, develop in the water-flea *cyclops*.   The adult worm is of considerable size, measuring from 50 to 80 cubic centimeters (20–32 inches) in length and a few millimeters in breadth.   It is of a white or yellowish-brown color.   When the worm begins to come out it should be left alone at first, as it may leave spontaneously.   However, it can be extracted by catching the protruding head between the split end of a smooth stick and winding it up on the latter, a few turns a day.   This is known as the Soudanese method of extraction.   Care should be taken not to break the worm during removal, as disastrous consequences may follow rupture.

The guinea-worm is widely distributed in tropical and sub-tropical countries, but occurs most frequently in Africa, Southern Asia, India, and Brazil.   In places where this parasite is known all water used for drinking purposes should be boiled, and no uncooked vegetables should be eaten.   Also, since the possibility of the worm entering the skin has not been definitely excluded, baths should be taken in clear water only.

FILARIA BANCROFTI.   Known quite generally as the *filaria sanguinis hominis* lives, as its name implies, in the blood.   Only the embryos, however, are really present in the blood, the adult worms having their habitat in one of the larger lymph

vessels of the trunk. The mature parasites measure
from 83 millimeters (male) to 155 millimeters (female)
long, by 5 millimeters broad; the embryos are about
the diameter of a red blood-corpuscle in thickness and
about 30 times as long. This filarium is widely dis-
tributed, being found in the Southern United States,
South America, India, China, Japan, West Indian
Islands, etc.

The most important lesions resulting from the para-
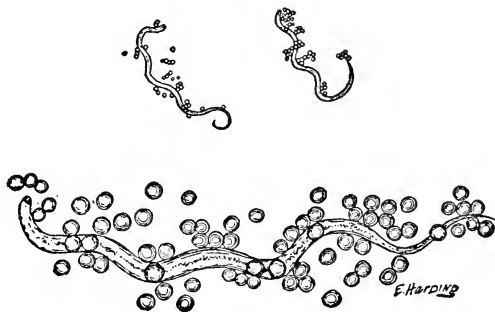
Fig. 7.—Larval *filaria bancrofti* in blood. (Coplin.)

site and its embryos are those due to obstruction of
important lymph channels, which leads to a hyper-
plastic condition of the tissues of the parts affected.
On account of the huge enlargement of the parts, and
their peculiar varicose appearance, the disease is called
elephantiasis. The disease is never general, affecting
only either one or both legs, the scrotum (lymph scro-
tum), one or both labia, or a breast, etc.

Filarial embryos are looked for in fresh blood-specimens the same as for malaria. There is a peculiar periodicity about their appearance in the peripheral circulation in the respect that they are found only at night.

Mosquitoes (culex) act as intermediate hosts for these filaria, abstracting the embryos from one person and inoculating them into others. Persons suffering from filariasis are therefore not only a danger to themselves (on account of repeated inoculations) but to others who may chance to be bitten by infested mosquitoes. In man again, the embryos mature, reach a lymph vessel and there begin producing fresh embryos.

Hæmatochyluria is also caused by the *filaria sanguinis hominis*. However, both this and *elephantiasis* may be due to other causes.

Besides the above filaria, two others are recognized by Manson, the *Filaria diurna*, the embryos of which are found in the peripheral circulation during the daytime only, and of which Manson suspects the *Filaria loa* to represent the adult worm, and the *Filaria perstans*, which the same author regards as the cause of a skin eruption, *craw-craw*, found on the west coast of Africa.

FILARIA LOA. A round worm of whitish or yellowish color, from 20 to 40 millimeters (1 and 2 inches) in length by 3 to 5 millimeters in breadth, and found in the subcutaneous tissues, usually of the face, but more especially in the conjunctivæ. Its movements in the skin, which are visible to the eye,

cause considerable itching and pain, and in the eyelids inflammation and swelling. The parasite is indigenous to the western coast of Africa, and is of common occurrence among the natives.

Both Americans and Europeans (chiefly missionaries) have harbored *filaria loa* after a residence in Africa, and had them removed on returning to their respective countries. Ward records the history of seven such cases observed by physicians in various parts of the United States, and has studied the specimens in a few of them. He concurs with Manson in the opinion that this filaria is a more mature form of the *Filaria diurna*.* Removal of the parasite is accomplished by grasping the worm firmly through the cuticle with forceps, and cutting down upon it with scissors or knife. Care should be taken that the skinhold on the worm is not loosened until the worm itself is grasped, or it may escape into the deeper tissues. The embryos of the worm are believed to be inoculated into man by an intermediate host, either a fly or mosquito. Prophylaxis in filaria loa is the same as for malaria.

The *trichocephalus dispar* (*whip-worm*) is TRICHIURIS a common parasite of the intestinal tract, TRICHIURA. particularly the cæcum. Universally distributed, it apparently does little or no harm, although anæmia and diarrhœa have occasionally been ascribed to its presence. Both the worm and its

* See Bul. Univ. of Neb., January, 1906.

eggs are quite characteristic and easily recognized. The living worm is seldom found in the stools.

STRONGY-LOIDES INTESTIN-ALIS.   Occurs in the stools in endemic diarrhœa of hot countries (Cochin-China). Has also been described in this country by Thayer. Infestment only produces symptoms when the parasites are present in large numbers. Eggs of the parasites are probably ingested with drinking-water.

TRICHINELLA SPIRALIS (Trichina spiralis).   Trichiniasis, as infestment of the body with the *trichinella spiralis* is called, is brought about by eating insufficiently cooked or raw meat (usually pork) which contains the larval forms. The young embryos which are set free in the stomach by digestion of their capsules, reach maturity in the small intestines in about three days. The females then give birth to innumerable larvæ—8,000 to 10,000, it is said—which are discharged directly into the lymph stream, whence they finally reach the blood and are distributed to their points of election, the voluntary muscles. Here the young worms become encysted, i.e., each one arranges itself in a spiral, and becomes surrounded by an inflammatory capsule. It is to the encapsulation of the embryos, together with a poison which is possibly set free by them, that the symptoms of trichiniasis are due.

A   B

FIG. 8.—*Trichiuris trichiura*, natural size: *A*, male; *B*, female. (Tyson.)

The female trichinella is a fine thread-like worm measuring from 3 to 4 millimeters long; the male is smaller, measuring 1.5 millimeters, and has two little appendages from the hinder end (bifid).

Practically all domestic animals may act as host for the trichinella, but infestment in man is seldom due to any other meat besides pork. The disease occurs wherever pork is eaten. In suspected cases the worms should be sought in the stools, or embryos may be obtained by removing a small fragment of the pectoral or biceps muscle under local anæsthesia.

FIG. 9.—*Trichinella spiralis.* Encapsulated larva in muscle. (Tyson after Braun.)

If pork or other meats are suspected of containing *trichinella*, the latter may be easily demonstrated by treating a thin section of the tissue with a solution of caustic potash (1–10) and viewing it with the low-power lens of a microscope.

Should the specimen be very fat, treat it with ether or dilute acetic acid first and then with the caustic potash solution.

ASCARIS LUMBRI-COIDES.

This, the common round worm of children, makes its home in the small intestines of man.

It is the commonest human parasite, being universally distributed.

The worm, which is from 4–8 inches (male) to 7–12 inches (female) in length and pointed at both ends, is transversely striated and exhibits four longitudinal bands. It has a yellowish-brown or reddish color. Usually the host harbors only a few adults—but there may be many. The eggs of the worm, and occasionally an adult parasite, are passed in the stools.

The migrations of these worms are remarkable, as they may crawl into the stomach and be vomited, or pass the whole length of the œsophagus into the nose, the middle ear, or the mouth. They have frequently been discovered in the gall-bladder, and have also been known to cause intestinal obstruction. Ordinarily symptoms of their presence are absent, or are limited to minor nervous disturbances, such as irritability, picking at
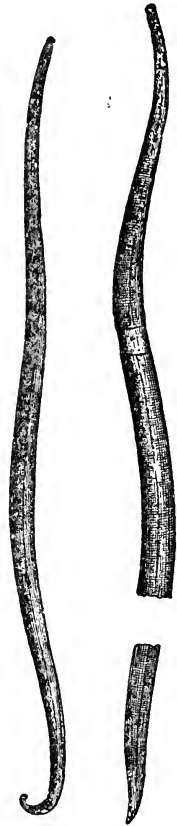
FIG. 10.—*Ascaris lumbricoides:* to left, male in lateral aspect; to right, female, ventral aspect, natural size. (Tyson after Railliet.)

the nose, and nocturnal grinding of the teeth. However, convulsions, epileptiform attacks, vertigo, and chorea, have also been described. The worms are quickly expelled by santonin (gr. $\frac{1}{2}$–1 for child, gr. 1–2 for adult) given either alone and followed by the same quantity of calomel or a saline purge; or equal quantities of santonin and calomel may be given night and morning until bowels are well moved.

The parasite is contracted from water or food containing the ova, so that a host may not only convey the parasites to others, but may re-infect himself.

OXYURIS VERMICULARIS. Also known as the *pin-worm*, *thread-worm*, and *seat-worm*, has its habitat in the cæcum, colon and rectum. It is a very common human parasite the world over. Found particularly in children, there is no period in life when they may not be contracted.

As its name implies, it is a small thread-like worm from 4 millimeters (male)–10 millimeters (female) in length, and is readily seen on examination of the stools. The eggs, which are also passed in the stools, are probably taken into the stomach with water or salads, or directly from the contaminated hands of the host.

The symptoms occasioned by the parasite are irritability, nocturnal restlessness, and itching, particularly about the anus. The worms may leave the rectum at night and deposit eggs on the perineum—or in females

may invade the vagina.   They have been found in the appendix.

Treatment is with santonin as in infestment with *Ascaris Lumbricoides*, and the daily irrigation of the colon with strong salt water.   These measures, however, do not always effect expulsion, and the worms may be parasitic for years despite every effort to dislodge them.   Self-pollution may be responsible in some cases, at least, for the obstinacy with which they resist removal.

UNCINARIA DUODENALIS.   The Uncinaria duodenalis (*strongylus duodenalis, anchylostoma duodenalis, hookworm*), is a parasitic worm which has its habitat in the duodenum, the jejunum, and occasionally the colon.   The condition to which
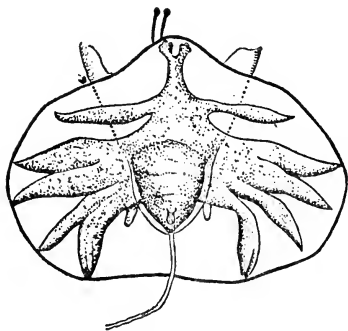
FIG. 11.—Tail, with expanded bursa, of male *uncinaria duodenalis*. (Tyson.)
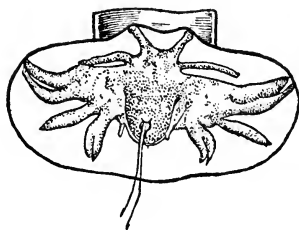
FIG. 12.—Tail, with expanded bursa, of male *uncinaria Americana*. (Tyson.)

it gives rise is known under as many names as the parasite, viz., anchylostomiasis, uncinariasis, hookworm disease, Egyptian chlorosis, etc.

Infestment is common in both the Old and the New World, although two distinct species of worms are concerned; the Old-World *Uncinaria duodenalis*, and the New-World *Uncinaria Americana*. The disease, which is characterized by a grave anæmia, and in untreated cases has a large mortality, is widely distributed in tropical and sub-tropical countries. There are also endemic foci in temperate climates. The island of Porto Rico seems to suffer more from this parasite than any other country, one-fourth of the total deaths in a single year (1903) having been ascribed to it. The anæmia prevalent in our own Southern states has been demonstrated by Stiles to have the same origin. In temperate climates, infestment is common in tunnel-workers and miners.

The adult worms, which measure from 8–10 millimeters (males) to 12–18 millimeters (females), live in the small intestines. From a bending backwards of the anterior extremity the name hook-worm has been derived. They are blood-sucking parasites, and by means of teeth and a powerful sucking apparatus attach themselves to the mucous membrane lining the gut. A few parasites do not cause symptoms, but where their numbers are large—in many cases 1000 or more—the drain upon the body is considerable, often ending fatally. In children their presence interferes with development. Only the eggs of the parasite appear in the stools, where they are usually present in enormous

numbers.   As they are voided in process of segmenta-
tion, they are easily recognized by examining a drop of
feces with the ordinary powers of the microscope.
Hatching takes place in water or moist earth, situations
in which the embryos may live for months.   The larval
uncinaria are taken into the body in the drinking-water,
or from the hands which have been soiled with earth
containing them.

Another mode of entrance is through the skin.   The
manner in which they get into the bowels is interesting.
From the skin the embryos are carried to the right side
of the heart and to the lungs.   Here they escape from
the pulmonary vessels into the air-spaces, travel up the
bronchi and larynx into the œsophagus, and by swallow-
ing find their way into the stomach and intestines.   It
is believed that the tropical skin affection known as
"ground-itch," and which is usually confined to the
ankles, is caused by the entrance of embryo uncinaria.
In the duodenum and jejunum full development is
attained, with subsequent reproduction of eggs.   The
cycle, it will be observed, is direct,

The diagnosis rests upon the presence of eggs in the
stools.   Stiles calls attention to the value of the blotting-
paper tests for blood when a microscopic examination
cannot be made.   Reference is made to this test in the
chapter dealing with the examination of the secretions
and excretions.

Expulsion of the parasites is ordinarily successfully

accomplished by giving, after a day of fasting, two doses of thymol (gr. 30 each) in brandy or whisky two hours apart, and two hours later a dose of castor oil. If ova are still present in the stools a few days later, the same treatment should be repeated.

Prophylaxis consists in not going bare-footed in regions where the disease prevails, in boiling the drinking-water, and in scrupulous cleansing of the hands before meals. The stools of persons harboring the parasites should be disinfected, and treatment instituted in all cases where eggs are found whether symptoms of the disease are present or not.

FLAT WORMS.

Parasitic flat worms are divided into two orders, the trematodes or flukes, and the cestodes or tapeworms. The former are distinguished by possessing a partial digestive canal but no anus; the latter by a complete absence of alimentary tract.

TREMATODES.

Distomiasis is the name applied to diseases resulting from trematodes or flukes. Flukes are mostly small, flat, leaf-shaped worms, which, as above noted, are without anal orifices. Usually they possess one or more suckers and occasionally hooklets. They are mostly hermaphroditic. Only the more important varieties will be referred to.

9

This, the Asiatic lung fluke, is of frequent
PARAGONIMUS occurrence in human beings in China,
(Distoma) Japan, Korea and Formosa, causing the
WESTER- disease known as pulmonary distomiasis
MANII. or parasitic hæmoptysis. In the United
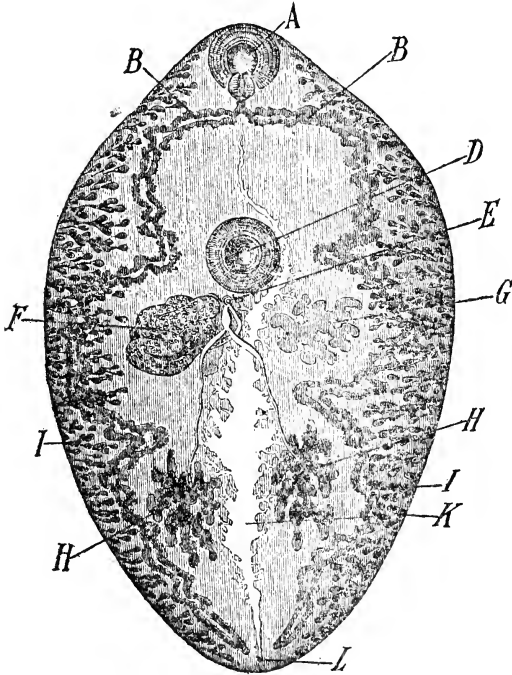
FIG. 13.—*Paragonimus westermanii:* (ventral view). 10×1. *A,* oral
sucker; *B,* ceca; *D,* acetabulum; *E,* genital pore; *F,* uterus; *G,* ovary;
H, testicles; *I,* vitelline glands; *K,* excretory canal; *L,* excretory
pore. (Braun, after Leuckart.)

States it is known only as a parasite of the dog, cat,
and hog. The adult worm is from 8–10 millimeters in

length by 4-6 millimeters in breadth, and almost as thick as broad. It is of a pinkish or reddish-brown color. Usually the worm inhabits the bronchial tubes of the animal upon which it is parasitic, but it has been found in other situations also.

The symptoms to which it gives rise are rarely serious, consisting of a chronic cough, and a rusty (sanguineous) expectoration. Occasionally there is severe hæmoptysis. Ova of the parasites are found in the expectoration, and from these the diagnosis is made. Nothing is known of the manner of infestment. Stiles sounds a note of warning by pointing to their presence in domestic animals.

LIVER FLUKES.

A number of liver flukes occasionally parasitic in man have been described, of which one, and possibly two, are of considerable importance.

OPISTHOR-CHIS SINENSIS. Foremost is the Chinese or Japanese liver fluke, *Opisthorchis sinensis*, which is common in China, Japan, and India. This species is somewhat larger than the lung fluke, being from 10–20 millimeters in length by 2–5 millimeters in breadth. As its name implies, it has its seat of election in the liver, particularly the gall-passages, and gives rise to digestive disturbances, jaundice, anæmia and dropsy. Years elapse between the time of infestment and death. The diagnosis rests on the presence of eggs in the stools.

Beyond the fact that the eggs will develop to a certain stage in water, nothing is known of the life-history of this parasite.

FASCICIOLA HEPATICA. Another liver fluke, common in sheep; it is also found in cattle, hogs, horses, and ruminants in general. They produce in sheep the so-called "liver-rot." The worm is a frequent parasite of animals in the United States. Few cases, however, have been described in human beings anywhere. The symptoms of infestment are the same as in the other liver-fluke diseases already described. The eggs of the parasite are found in the stools. They are taken into the body probably in water or upon raw salads.

SCHISTOSO-MUM HÆMA-TOBIUM (Bilharzio hæmatobia). This fluke is distinguished from other flukes already described by the fact that it is found in the blood, particularly the portal vein and its branches. The disease which it causes, hæmic distomiasis, Bilharziosis, or Egyptian hæmaturia, is prevalent in Egypt, Africa, Persia, and the west coast of India. It is said to occur in Cuba and Porto Rico also. Imported cases are occasionally encountered everywhere.

In this fluke the sexes are separate. The eggs of the parasite are the chief cause of mischief.

Symptoms of the disease are practically always referable either to the bladder or rectum. In involvement of the former viscus there is pain and burning over

the supra-pubic region, irritability of the bladder, and hæmaturia; in the latter, straining, tenesmus, and the passage of blood and mucus. Ova are found in either discharge, and the diagnosis rests upon their discovery.

Hæmic distomiasis is a very important disease, as its prevalence in many countries attests. Since communication with the East has become closer, a larger number of imported cases have been reported. Dr. Stiles is of the opinion that the United States will suffer from importation of parasites by troops returning from foreign service and by travelers. The same author leans to the belief that a snail acts as intermediate host for the hæmatobium. If this be true, before the disease can become endemic in the United States depends upon "whether there exist in the United States species of snails which can serve as intermediate hosts, and whether these snails actually become infected by persons harboring the parasite." Furthermore, if snails act as intermediate hosts, then "cases of infection are more likely to occur in rural districts than in cities, and *country physicians will be more likely to encounter them*" (Stiles).

CESTODES.

Cestodes or tape-worms are flat, segmented, ribbon-like worms which have their habitat in the small intestines. They are characterized by a complete absence of a mouth or digestive tract, and nourishment is maintained entirely by absorption of nutrient material

through the external covering. Depending upon the species, the length of the worm varies from a few inches (dwarf tape-worm) to thirty or more feet (Bothriocephalus latus). The adult worm consists of a head or *scolex*, a thin thread-like neck, and a body made up of conjoined segments or *proglottides*. The head is provided with suckers, in some species with hooklets also, by means of which the worm fastens itself to the gut and maintains its position. It is on account of these organs of attachment that the head is often difficult to dislodge. Yet it must be expelled if a cure is to be effected, since growth of the worm proceeds entirely from the head end. The neck is unsegmented. Behind the neck, the first segments are short and narrow, but they gradually increase in size until the adult dimensions are attained. The size of a segment is related to its maturity.

In each proglottidis are found both sexual elements in various stages of development. The more mature segments are situated towards the distal end of the worm and contain numerous ova, in each of which is an embryo worm. Segments containing embryos are said to be "ripe," and it is these which are constantly separating from the less mature and being shed in the stools. When they appear in the stools, two or more segments are usually found attached together. These may have the power of independent locomotion, a fact which should not mislead the observer into believing

that they constitute a whole worm. When eggs containing embryos are taken into the stomach of a suitable host—usually in water or food—the embryos are liberated, pass into the small intestines, the walls of which they penetrate, and reach various tissues and organs, the liver, muscle, brain, etc. Here they become encysted and develop into *cysticerci* or "bladder-worms," that is to say, they are converted after a few months into a cyst full of fluid. From a point on the inner wall of each cyst a little bud projects, which in time is converted into a tape-worm head or scolex, and a sac containing it. A cyst containing a tape-worm head is known as a "*measles*" or *cysticercus cellulosæ*. Flesh of this kind is said to be *measled*. As cysticerci the parasites live indefinitely until the flesh containing them is eaten by another host, in the intestinal tract of which they then grow into mature tape-worms. The cycle of the cestodes is therefore in two hosts, with possibly a short interval between spent in water. Tape-worms parasitic in man belong to two orders—the *Tæniadæ* and the *Bothriocephalidæ*. The first occurs in man either as "measles" or as tape-worms, the latter only as tape-worms. Ten species of tape-worms have been described, of which three, only, are known definitely to be connected with food. These are *Tænia saginata* (*T. mediocanellata*) due to measly beef, *Tænia solium*, to measly pork, and *Bothriocephalus latus*, to infested fish, such as sturgeon, pike, perch, and salmon.

TÆNIA SAGI- The unarmed or beef tape-worm is the com-
NATA (T. me- monest of tape-worms found in America.
diocanellata). It inhabits the small intestines.   In length
it varies between 9 and 24 feet.   The head,

which measures about 2 millimeters
in breadth, is pyriform and with-
out hooklets, but contains four
cup-shaped suckers on its ventral
aspect.   The ripe segments are
from 17–18 millimeters in length
by 8–10 millimeters in breadth.
Cattle act as intermediate hosts,
and eating uncooked beef contain-
ing the cysticerci gives rise to in-
festment in man.

Both eggs and proglottides are
passed in the stools.   The proglot-
tides are easily recognized and are
diagnostic of an adult worm.
Symptoms due to tape-worms may
be absent entirely, or may consist
of occasional colic and an abnormal
appetite.

FIG. 14.—*Tænia medi-
ocanellata.* (Gould, after
Leuckart.)

TÆNIA Or pork tape-worm is a rare parasite in
SOLIUM. the United States.   In Europe it is not
uncommon.   It is a smaller cestode than
tænia saginata; the head measures less than
the head of a pin (0.6–1 millimeter); the ripe proglottides

are 10–12 millimeters long by 5–6 millimeters broad; and the length of the whole worm varies between 6 and 9 feet. The head is provided with four suckers, and a double row of hooklets, a fact from which has arisen the name "armed tape-worm." The ingestion of insufficiently cooked "measled" pork is responsible for infestment.

Usually only a single worm is found in one individual, but more may occur. *Tænia solium* is a much more dangerous parasite than *tænia saginata* because man may be the host for both the adult and bladder-worms; on this account a person that harbors this parasite should be especially careful not to carry a soiled hand to the mouth or allow it to contaminate food.

The adult worm *per se* gives rise to few or no symptoms, but if its eggs are ingested, the embryos, besides being distributed to muscles, may also find lodgment in important organs, e.g., the brain, eye, liver, etc.

FIG. 15.—*Dibothrio-cephalus latus.* (Tyson, after Leuckart.)

DIBOTHRIO-CEPHALUS LATUS (Bothriocephalus latus). This, the longest tape-worm met in man, is commonest along the Baltic Sea, in Japan, and in Switzerland. It is also said to be of frequent occurrence in Munich. The parasite measures from 6 to 30 feet

or more in length. The head is narrow transversely (0.71 millimeters) and differs from the *tænia* in having two lateral grooves or bothridia as suckers. There are no hooklets.

Fish act as intermediate hosts for the measles, sturgeon, pike, perch, etc. In the stools of a person harboring the bothriocephalus, eggs characteristic of the worm are found in large numbers. These find their way into water, when the embryos escape from the eggs and lead a free existence for an unknown period. They are finally swallowed by their fish-hosts, from whom man in turn acquires the adult worm.

FIG. 16.—*Dipylidium caninum.* (Leuckart, after Weinland.)

DIPYLIDIUM CANINUM (tænia cucumerina). This is a dog tape-worm which is widely distributed. Its intermediate hosts are the dog-louse and flea, and the ordinary flea of man (*pulex irritans*). Its chief interest in human pathology is that children occasionally harbor the adult worm, contracting it from the dog's louse or flea.

HYMENOLEPSIS NANA. Known also as the "dwarf-tape-worm," is a short cestode parasitic in rats, mice, and man. The intermediate host is not known. The worm is known throughout Europe, and lately many cases have been reported from the Southern United States (Stiles).

Is found principally among the very poor. When many worms are present they may give rise to severe symptoms, and may even be a cause of death. The adult worm only measures from 10 to 15 millimeters in length. The head is provided with four suckers, and also with a single row of hooklets.

VISCERAL CESTODES.

Whereas adult cestodes which inhabit the alimentary tract occasion as a rule unimportant symptoms, localization in various organs of the "measles" or bladder-worms may be a very serious event. Fortunately man may act as host for the larval forms of only two tape-worms, viz., *Tænia solium* and *Tænia echinococcus;* and more fortunate still, such infestment is not common.

CYSTICERCUS CELLULOSA. Or "measles," it will be remembered, is the embryo stage of *Tænia solium* or pork tape-worm. Man usually harbors the adult parasite, but from the ingestion of ripe eggs he may also become the host of the larvæ. The symptoms of infestment depend on the localization of the cysticerci. Unless a vital organ is involved they may be trivial; but in the brain, cord, or eye, serious mischief results. In a few cases the presence of subcutaneous nodules excited suspicion, which was confirmed by removing one and examining with the microscope.

The adult form of this cestode is found in the dog, wolf, jackals, etc. Man harbors the larvæ. Infestment is practically only encountered where dogs are kept in close relationship with their masters, as in Iceland and Australia. In other countries sporadic cases are occasionally reported, usually in foreigners, who probably contracted the disease elsewhere. The adult worm is a tiny cestode from 2.5–5 millimeters in length, with a head provided with four cup-shaped suckers and a double row of hooklets. When man ingests the ripe ova of this worm, visceral infestment (*Echinococcus* disease) ensues. Localization may be in any organ, the liver, lungs, kidney, etc. Huge cysts enclosing numerous other cysts are stages in the development of the embryos, countless numbers of which may develop from a single egg, thus differing from the cysticercus of other cestodes in that a single egg gives rise to only one embryo.

TÆNIA ECHINOCOCCUS.

FIG. 17. — *Tænia echinococcus:* a, adult; b, head from echinococcus cyst. On left a detached hooklet, as seen in fluid from cyst. (Coplin and Bevan, after Leuckart.)

INSECTS.

Parasitic diptera, or two-winged flies,
PARASITIC   occupy an important position in relation
DIPTERA.   to disease, since various species of this
order are harmful to man in a number of
ways. Besides the inconvenience that large numbers
of diptera cause by their bites (e.g., jigger-flea, bed-
bug, etc.), incidents which are not always unattended
with danger to health and life, others of this order may
burden the economy with their young. The latter is
accomplished in one of two ways: 1. By depositing
their eggs or larvæ either upon wounds or in cavities
(of the body) leading to the exterior, such as the nose,
ears, vagina, etc., or by placing them beneath the skin.
In all such instances the larvæ feed in the places depos-
ited and cause such annoyance as their growth and
migrations excite.

2. In other instances the eggs or larvæ are taken
into the intestinal tract with food or drink, and are
voided in the feces.

Myiasis is the technical term used to denote the con-
dition in man in which the larvæ of diptera are
parasitic; and depending upon whether the larvæ
(maggots) are upon the exterior or interior of the body
it is designated external or cutaneous, and internal
myiasis, respectively. Where maggots are found in the
stools care must be taken to exclude the possibility of
flies having had access to the stools, since living young

may be deposited upon them by the latter.   Mosquitoes belong to the two-winged flies or diptera, a fact which, if previously unknown to the reader, will now suggest a third way in which these insects are harmful, viz., by acting as secondary hosts for other human parasites. Because the relationship of mosquitoes to malaria, yellow fever and filariasis, has already been sufficiently elucidated, additional reference to them here would be superfluous.

Finally, diptera may accidentally convey disease-agents either upon their bodies or in their feces, factors in disease that have also already been considered elsewhere.

To the Œstridæ or bot-flies belong those species the larvæ of which are parasitic upon man.

ŒSTRUS HOMINIS.   Dermatobia noxialis Goudot. This fly is a common pest in tropical America. Known under numerous names, viz., Ver macaque (Cayenne and Mexico), Ura (Brazil), Torcel (Costa Rica), its larvæ are deposited upon exposed portions of the body, whence they work their way into the subcutaneous tissues. Here, if undisturbed, they complete their growth and issue when mature from the abscesses to which their presence gives rise. The larvæ are quite characteristic in that one end (head) is quite large in comparison with the other, and there are minute spines on segments two and three.

DERMATOBIA
CYANIVEN-
TRIS.
The larvæ of this fly are also common parasites. They are distinguished from the larvæ of *noxialis* by having no fine spines on segments two and three, but a row of strong hooks projecting from the hind margin of segments four to seven (Blanchard).

COMPSOMYIA
MACELLARIA.
Compsomyia macellaria is known throughout America, but cases of myiasis due to its larvæ are only common in the warmer portions. The larva is known as the "screw worm." The bot-fly itself has a reddish-brown head, a bluish-green thorax and abdomen, and the thorax is further distinguished by three longitudinal black stripes. The eggs are deposited upon the skin, where they quickly hatch, and the larvæ then work their way into the subcutaneous tissues and produce abscesses. But here and there eggs are laid in the nostrils of individuals asleep. In this situation the growing worms produce a terrible state of affairs, since in their burrowings they may destroy all the tissues of the soft palate and posterior pharynx, and may even lay bare the hyoid bone. As many as three hundred maggots have been discharged from the mouth and nose of a single individual.

SARCOPHAGA
CARNARIA.
This, the common blue-bottle or flesh-fly, occasionally lays its grubs in old ulcers, which then have the appearance of "living," that is to say, the maggots are as

actively motile as when ordinarily seen in decomposing material.   Solutions of bichloride of mercury (1–1000) quickly rid the host of these parasites.

PULEX IRRITANS.   Or common flea is a minute red or dark-brown insect which is only parasitic upon man in countries where it is present in great numbers.   It is particularly trouble-some in hot countries.   Its eggs are not laid in the skin, but in cracks of floors, sawdust and dust.   Its bites are irritating and may cause wheals (hives).

FIG. 18. — Larva of *pulex irritans*, (Gould.)

SARCOPSYLLA (pulex) PENETRANS.   The sand-flea, "jigger," "jig-ger-flea," "chigœ" or "chique" is a more serious parasite than the common flea.   The impreg-nated female burrows into the skin to breed her young, which are very numerous.   Favor-ite situations are the lower extremities and feet, particularly beneath the nails of the toes.   Painful swellings, abscesses, and ulcers often result.   The in-sect is principally found in Central and South America, and South Africa.   The fleas may be picked out with a needle, but one should be careful to extract them whole since distressing sores may otherwise result.

CIMEX LECTULARIUS.   Bed-bugs are true cosmopolitans, being found the world over.   The body is thin and flat and oval in outline.   Its color varies from a grey to a dark reddish-brown.

It has a characteristic odor. It is entirely nocturnal in its habits, sucking blood at night and hiding in the cracks of the bed, of cupboards, etc., in the daytime. This pest can usually be eradicated from beds, etc., by washing with bichloride of mercury (1-500), pure carbolic acid, or kerosene.

Where the room or building is so badly infested that these measures do not suffice, fumigation with sulphur
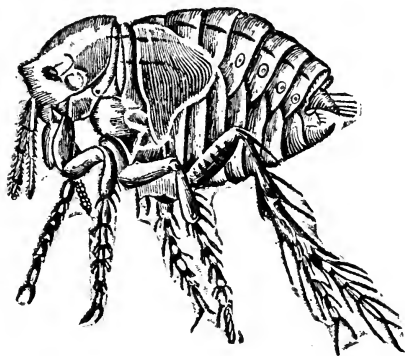
FIG. 19.—*Sarcopsylla* (*pulex*) *penetrans:* young female, enlarged. (After Braun.)

FIG. 20. — B e d-b u g; 1, side view; 2, back view.

(1 pound to each 1000 cubic feet of space) is a reliable measure. No moisture is required as in the case of fumigation against bacteria, so that fabrics are not necessarily injured, and the exposure need not be longer than two or three hours.

PEDICULI.   Pediculi or lice are found chiefly in two situations on the body, in the hair of the head (pediculi capitis), and in the pubic hairs (pediculi pubis or inguinalis).

10

Another louse is found in the seams of the clothing (pediculus vestimenti).

PEDICULUS CAPITIS.   This is usually found in uncleanly persons, but may accidentally invade the fastidious. A peculiarity of this louse is that its color varies with its hosts, that is to say, it is

FIG. 21.—Ovum of head-louse glued to hair; ×70. (Tyson, after Braun.)
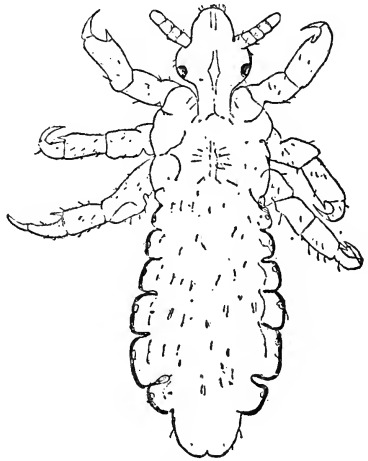
FIG. 22.—*Pediculus capitis.* × 15. (Tyson, after Braun.)

light grey on a Caucasian, yellowish or dark-grey on the Mongolian, and black on the Negro. The individual lice are difficult to find, but their presence is assumed by finding eggs or "nits." These are little oval glistening bodies attached to the hairs. Treatment consists in cutting the hair and washing with kerosene.

PEDICULUS
PUBIS.
This louse is commonly known as the "crab-louse," from its resemblance to a crab. Its nits are attached to the hairs quite close to the skin. Oftenest the nits are only found in the pubic or adjacent hairy parts, but they may be present on the hairs of the chest, the axillæ and even on the eye-brows.

Where the insect bites, a minute slate-colored lesion results which itches intensely.

The parasite is ordinarily conveyed from person to person during sexual congress, but sleeping with a person harboring the parasite may be the means of contracting it.

The "toilet" has also been held responsible.

Both the parasite and its nits are quickly killed by smearing

FIG. 23.—*Pediculus vestimenti:* × 10, circa. (Tyson, after Braun.)

the affected parts with mercurial (blue) ointment.

PEDICULUS
VESTIMENTI.
The clothes-louse makes its home in the seams of the clothing and underwear. Its bites cause itching. Scratch-marks over the back and around the waist-line usually evidence its presence. Boiling or steaming the clothing, or hot ironing, are easy means of ridding a person of the parasite.

ACARUS
SCABIEI
(itch-mite).

Or Sarcoptes hominis, the itch-mite, is another parasitic insect which forms burrows in the skin. Only the female produces lesions, the purpose being the deposition of her eggs. The portions of the body selected are those where the skin is thinnest, viz., in the webs between the fingers, at the bend of the elbows, in the axilla, upon the penis, at the bend of the knees, and about the ankles. In children, burrows may be found over the whole body.

Where the mite penetrates the skin a little vesicle is formed, and the direction of the burrow is indicated by a rough, dark line. However, because intense itching always accompanies the insect's activity, the only lesions discoverable may be scratch-marks. Itching is most complained of at night, the period when the female is active. The itch-mite is so small that it is seldom seen and the diagnosis of its presence is made entirely from the character and situation of the lesions. It is of historical interest that the first Napoleon was a sufferer from "itch" for ten or twelve years until cured by the physician Couvisart.

The parasite is contracted by intimate contact with a person who harbors it.

Eradication of the mite is easily accomplished by scrubbing the lesions with soap and a soft brush, followed by rubbing Balsam Peru well into the bur-

rows. Sulphur ointment, although highly recommended, is not nearly so efficacious.

LEPTUS AUTUMNALIS.
The harvest-mite, which is active during July and August, is a red-colored larvæ of a variety of *Trombibidæ*. The latter lives on grasses, bushes, and grain, and its larvæ alight on man as occasion offers. The red papules and wheals which it produces are usually
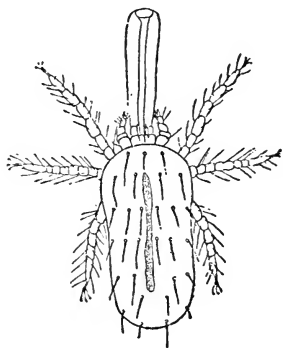
FIG. 24.—*Leptus autumnalis:* enlarged. (Tyson, after Braun.)
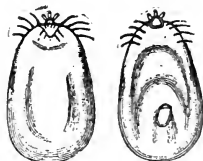
FIG. 25.—Female of *Ixodes ricinus*, gorged full, ventral and dorsal surfaces. ⅔. (After Pagenstecher.)

situated on the ankles, but may also be found on other parts of the body.

IXODES RICINUS.
The wood-jack or wood-tick is a fairly large yellowish-brown tick, with a black head and a leathery body. It is common upon grasses and bushes, and from these places gets upon man and beasts. It is a blood-suck-

ing parasite, burying its head and sometimes almost its whole body in the integument.

In various localities, e.g., Africa, and Montana, U. S., fevers are described which are believed to be due to the bites of ticks (tick-fever, *Ixodiasis*); the evidence in favor of such relationship, however, is contradictory.

CHAPTER VI.

AVENUES OF EXIT OF INFECTIOUS AGENTS AND PARASITES FROM THE BODY.

The source of every infectious disease is always another infectious disease, that is to say, the infectious agent has come directly or indirectly from some other person. The spontaneous generation of disease is no longer believed in, no more than is the spontaneous generation of life from lifeless matter. It is true that we cannot always trace the connection between successive cases of the same disease, but such instances are few in comparison with the number in which the relationship can be proven. However, what has definitely been determined is the manner of exit from the body of micro-organisms in practically all of the infectious diseases of both known and unknown origin. This, from a sanitary standpoint, is of surpassing importance, because it permits of our destroying the infectious agents at their source and when concentrated, and thus give them no opportunity to be scattered, so to speak, to the four winds.

It is self-evident that the communicability of a disease bears a definite relationship to the number of

exits open to the causative agents, and that one disease may, therefore, require greater precautions than another to prevent its spread. In no field of public utility does knowledge confer greater power than in sanitary science, and in this matter of the exit of micro-organisms from the body in disease we have the key to the happiness of families, the prosperity of nations, and to victory in wars. Moreover, it robs disease of its terrors by suggesting protective measures which can be relied upon to be entirely efficient. If all of the infectious agents were efficiently dealt with upon their exit from the body, the various diseases to which they give rise would in time become traditions; but until Arcadia is attained this will not be done.

Sanitarians in order to work in an enlightened manner must inform themselves of both the direct and indirect sources of disease. A direct source is a diseased person, so that this study begins with the elimination of infectious agents from the body.

In general it may be stated that microbes leave the body in six ways:

1. In the expectoration and nasal secretion.
2. In the stools.
3. In suppurations discharging externally.
4. From the skin.
5. In the urine.
6. From the blood through the bites of suctorial (biting) insects.

Perhaps for completeness we should add that they also make their exit in the lachrymal and vaginal secretions; but since there is no specific infection of the uterus, and only a few of the conjunctiva, these exits are not of sufficient importance to justify an individual place in our division of the avenues of exit.   Furthermore, the inflammatory conditions found in both these situations might, with perfect propriety, be included under division three.

The exit of a micro-organism from the body depends upon the character and location of the disease, namely, whether it be local or general.   If a disease is localized in such a portion of the body as communicates with the exterior, the germs make their exit by that channel. Thus, in inflammatory conditions of the lungs, the offending microbes are discharged by way of the passages that lead from them to the exterior.   Similarly, in infections of the uterus the infecting agents make their exit by way of the vagina.   But if, on the other hand, the disease be general, that is, if the germs are circulating in the blood, there may be various avenues of exit, the urine, the skin, the sputum, the stools, and sometimes, through the bites of insects.

Until quite recently, many diseases that we now know to be general were looked upon as localized infections, and therefore their agents were supposed to leave the body by a single channel; but later researches have so modified our views that we now believe there are very

few infections in which the agents do not pass to the exterior in a variety of ways. In those diseases which are both local and general we find the most numerous avenues of exit, and in them it is possible for the infectious agent to leave the body in every one of the six ways enumerated above. An example of a common disease in which the germs make their exit in at least five ways, with a possibility of six, is furnished by typhoid fever; in its incipiency the bacilli are localized in the lower portion of the small, and the beginning of the large intestines—but they soon invade the blood, and by the latter are so distributed that they may be eliminated in any of the secretions, in localized suppurations, and even by the bites of insects.

It often happens in the course of a disease that a micro-organism will make its exit in some other way than the channels ordinarily followed. This occurs principally when complications arise. Therefore, *whenever, in the course of an infectious disease, complications arise in which there is a purulent or other discharge to the exterior, these discharges should be regarded as fresh avenues of exit for the specific micro-organisms.*

To be sure, complications are often due to microbes of a species different from the one causing the primary infection; but in the absence of definite information to the contrary, it is a safe rule to regard complications as due to a migration to another part of the body of the first invader. Thus, when an otitis media (middle-

ear disease) complicates diphtheria, or follows as a sequela, the discharge from the ear is quite likely to contain diphtheria bacilli; and in the same way the purulent pleurisy (empyema) which often complicates pneumonia, is usually an extension to the pleura of the same micro-organism which caused the pneumonia. Failure to give due regard to such considerations may lead in certain of the infectious diseases to serious consequences. Cases in point are otitis media following diphtheria and scarlet fever, the discharges from the throat and ear in either case remaining infectious for weeks after recovery. The virus of scarlet fever is especially tenacious in that way, and the records of the disease are full of instances in which it has been conveyed by children with discharging ears after release from quarantine.

EXPECTOR-
ATION.
The sputum is a prolific source of infection, since always in the expectoration, to a lesser extent in the nasal secretions, are discharged the microbes that give rise to inflammatory conditions of the air-passages: the lungs, the bronchi and trachia, the pharynx, the buccal and nasal cavities. The inflammations in question may be primary in the part affected, or secondary to an inflammatory process elsewhere; or they may be part of a general disease. An example of these various conditions is found in pneumonia. Pneumonia may occur as an independent infection; it may be secondary to an inflammatory

process elsewhere, e.g., abscess of liver; or it may be part of a general infection, such as typhoid fever.

In either the sputum or nasal secretions, or both, therefore, are always found the infectious agents of diphtheria, influenza, scarlet fever, whooping-cough, mumps, rabies (hydrophobia), pneumonia, tonsillitis, bronchitis, pulmonary tuberculosis (consumption), tubercular laryngitis, cerebro-spinal fever (secretion from nose ?), measles, acute glanders (farcy), actinomycosis, small-pox, leprosy (when lesions are in nose), aphthous fever (foot and mouth disease,) echinococcus disease of the lungs, syphilis (primarily in mouth), and typhus fever.   **Parasites**—eggs of *Paragonimus (Distoma) Westermanii,* in parasitic hæmoptysis.

In the same secretions, but only when the respiratory passages are also involved in the disease, are found the microbes of typhoid fever, anthrax, bubonic plague, actinomycosis, amœbic dysentery (in perforation of abscess of liver into lung), syphilis (secondary), tuberculosis, leprosy, glandular fever (?), gonorrhœal stomatitis (child infected during parturition).   **In the vomitus,** it is always to be remembered, such organisms as cause intestinal diseases, or intestinal parasites and their eggs, may be ejected.   Thus cholera spirilla have been found in vomited matter, as well as the eggs and even segments of tape-worm.

FECES.   As an avenue of exit for micro-organisms the stools rank with the sputum in importance, if they do not surpass it.   Besides

the fact that there are as many infectious processes localized in the intestinal tract as in the air-passages, in all of which the microbes are eliminated in the stools, the germs of every general disease find their way into the same passage by way of the bile. Furthermore, a host of animal parasites are found sporadically in the intestinal tract from which they or their eggs escape by the natural passages. With one exception, i.e., in consumption, the sputum is chiefly dangerous to those immediately surrounding the patient; and even in this disease the infection is mostly limited to dwellings, factories, and offices. The feces, on the contrary, are the source of certain wide-spread infections at great distances from the patient. This happens because the micro-organisms causing these diseases are capable of growth outside the body, particularly in water, and because they are such as must be taken into the alimentary canal to produce their effects.

In the matter of disposal of sewage we are still barbarians, if not criminals; and the diffidence with which the public views the pollution of its water-supply by alvine discharges is a shame to our much vaunted civilization. In fact, it is little short of miraculous that a stop has not been put to it long ago, when one considers the wide publicity given to the actual and possible dangers of such a filthy and obnoxious practice. But it *is* permitted to go on, with the result that there is scarcely a city or town that does not drink water which

is polluted by the sewage of another city; and the former places in turn pour their disease-carrying waste into other rivers and lakes which supply the drinking-water to still other communities. Thus is a "vicious circle" of infection maintained. Is it surprising then that in this way many diseases are spread, such as typhoid fever, cholera and dysentery, and that the parasites of numerous intestinal disorders are distributed to new hosts?

But because the general public regards with indifference the infliction of so much unnecessary suffering and death is not a reason for physicians and nurses taking the same attitude. Contrari-wise, since their chosen fields give them a more intimate knowledge of the many sources of disease springing from ignorance and folly, and since they are thereby more impressed with the necessity of acting in advance of actual personal and public calamity, it is part of their duty to humanity to take the initiative in matters germane to their work. Hence if the manner of sewer-disposal is a shame and blot upon our civilization, the same strictures are applicable to physicians and (especially) nurses if fecal matter from a patient is infectious when disposed of. Rendering the stools innocuous is a small yet imperative part of a nurse's daily routine, upon which the physician should insist, and which the nurse should conscientiously perform. At the bedside, better than anywhere else, we command the situation in so far as the spread of disease by sewage is concerned; and were disinfection

here always practised, we would be going a long way towards balancing the harm that comes from the homicidal practice of polluting our water-supplies with every conceivable filth. Viewed from this standpoint, therefore, the stools assume in disease an importance impossible to measure.

To disinfect the feces in every disease would be a waste of time and money, besides being unscientific; hence the reason for knowing those diseases in which it is called for. The germs which cause the following diseases are always passed in the stools: Typhoid fever, Asiatic cholera, dysentery (both amœbic and bacillary), tuberculosis (when the bowel is affected, or the germs are swallowed by the consumptive), bubonic plague, cholera infantum, and anthrax; in small-pox, measles, scarlet fever, and chicken-pox, although the etiological factors are not known, there is no doubt that they are expelled in the feces.

The parasites, and the eggs of parasites, found in the stools are: Eggs and segments of various tape-worms, eggs of round-worms (*Ascaris lumbricoides*), eggs and worm of pin-worm (seat worm, *Oxyuris vermicularis*), eggs and worms of *uncinaria* (in hook-worm disease, *Uncinariasis*), worms of *Strongyloides Intestinalis* (Endemic diarrhœa of hot countries), eggs of *tricocephalus dispar*, ova in *Hepatica Distomiasis*, ova in *Hæmic Distomiasis* (*Bilharziosis*, Egyptian hæmaturia), larvæ of common house-fly.

URINE.

The urine is a frequent avenue of exit for bacteria. They are found in it in practically all diseases in which bacteria are circulating in the blood (bacteriæmia, septicæmia), and also in infections of the genito-urinary organs generally. In all the eruptive fevers of known or unknown origin, the urine should be regarded as infectious. With reference to this secretion the profession learned a valuable lesson in the case of typhoid fever; for a long time the urine in this disease was entirely disregarded as a source of infection, yet the last few years have taught us that as an avenue of exit for the typhoid bacilli, it is infinitely more dangerous than the stools. In the stools, the putrefactive bacteria which are always present, are far more vigorous than the typhoid bacilli, so that if typhoid stools are allowed to stand a day or two, the typhoid bacilli disappear. After recovery the bacilli are not found in the stools unless the biliary passages are infected. The urine, on the other hand, during the whole course of the fever, constantly contains the specific bacilli, often in such numbers as to make it cloudy (bacilluria); and what is far more important, the bacilli may be present for months and years after recovery unless means are taken to eradicate them. In view of the latter fact it is a routine practice in many hospitals to give during convalescence from fifteen to twenty grains of urotropin daily, or to wash out the bladder once a day, for several days after the temperature has reached

the normal, with a solution of bichloride of mercury (1–20,000).

The urine contains the infectious agents in the following general diseases: Tuberculosis (also consumption?), pneumonia, typhoid fever, anthrax, bubonic plague, influenza, malta fever, and in all other bacteriæmias or septicæmias which are usually classed as blood-poisoning and are due to the streptococcus of erysipelas (streptococcus pyogenes), or to the common bacterium of suppuration (staphylococcus pyogenes aureus).

IN URINE IN LOCAL DISEASES. In local disease of the genito-urinary organs the specific micro-organisms of the following infections are found: Gonorrhœa, tuberculosis, syphilis (when chancer or secondary lesion is in the urethra), in all infectious diseases of the kidneys, bladder, etc.

PARASITES AND EGGS OF PARASITES IN URINE. Eggs of parasites in *Hæmic Distomiasis* (*Biharziosis*, Egyptian hæmaturia), embryos in hæmatochyluria (associated with *filariasis*).

SKIN. The skin gives off freely in scaling the infectious elements of many general diseases, among which are chiefly the agents of the eruptive fevers, such as scarlet fever, small-pox, measles, chicken-pox, erysipelas, typhus fever, rubella, cerebro-spinal fever (?), and syphilis (secondary). In typhoid fever, typhoid bacilli have been found repeatedly in the rose spots.

11

In local affections of the skin, the agents
LOCAL   in the following diseases are cast off:
DISEASES   Cutaneous actinomycosis, blastomycetes,
OF THE SKIN. ring-worm of various parts of the body,
tinea sycosis (barber's itch), favus, tinea
versicolor, impetigo contagiosa, furunculi (boils), malig-
nant pustule (local anthrax), erysipelas, pinto (spotted
sickness), mycetoma (Madura foot), lupus vulgaris
(cutaneous tuberculosis), syphilis, leprosy, yaws, glan-
ders (farcy), etc.

Animal parasites are found in these affec-
PARASITES   tions of the skin: Scabies, pediculosis
OF SKIN.   (pubis, capitis, vestimentorum), Craw-craw,
and Guinea-worm disease (*Dracunculus
medinensis*). The larvæ of the common house-fly are
sometimes found in wounds, and the grubs or larvæ of
special flies (bot-fly, gad-fly, etc.), in tropical and sub-
tropical countries, quite frequently take up their abode
beneath the skin.

The blood as an avenue of exit for infec-
BLOOD.   tious agents was a sterile field for research
until the relationship of a biting insect to a
disease was established by the discovery, in 1893, by
Theobald Smith, that a tick is the intermediate host for
the micro-organism of Texas cattle fever.   Long before
this discovery physicians had suspected that mosquitoes
played a rôle in both malaria and yellow fever—but
the proofs were lacking in both diseases.   These have

now been supplied, with additional evidence that another disease, filariasis, is conveyed in the same way. It is quite probable that many communicable diseases whose infectious agents are still a mystery may be transmitted by suctorial insects—at least this is suspected—but these are facts for future investigations to disclose.

It is often as important to know the manner of transmission of a disease as its cause, because this may supply the only data for combating it.   Just this much is the sum of our knowledge of yellow fever, yet that it may be controlled has been conclusively proven by Major Gorgas of the U. S. Army, in Havana, Cuba, and by officers of the U. S. Public Health and Marine-Hospital Service, in Louisiana last year (1905).   The yellow fever commission appointed by the Surgeon-General of the U. S. Army, the commission to which we owe our knowledge of the transmission of yellow fever by mosquitoes, after it had made the latter discovery, was able also to eliminate every other avenue of exit for the causative agent except the blood, and thus made clear the futility of attempting to circumscribe the disease by disinfection of secretions, fomites, etc.   It further showed that extermination of mosquitoes offers the only solution of this sanitary problem, because in no other way can this unknown virus get out of one patient's body and into another.   Therefore, when we say a micro-organism makes its exit in the blood, it is understood that this is accomplished through the bite of an

insect. From the blood, through the bites of suctorial insects, the microbes of malaria, yellow fever, filariasis and trypanosomiasis (sleeping-sickness), always make their exit. Dengue is also believed to be conveyed in this way. In typhus fever, bubonic plague, typhoid fever, and the bacteriæmias generally, there is always the possibility of microbes being extracted when a patient is bitten. Bed-bugs may suck out the spirilla in relapsing fever, to prove which the disease has been produced in a monkey by inoculating it with blood obtained from a bug that had bitten another monkey suffering from this infection.

SUPPURA-TION. In suppurative processes the micro-organisms causing the trouble are always expelled in the escaping material. In the following specific infections the offending microbe is discharged in the pus: Erysipelas, anthrax (malignant pustule), glanders (farcy), malignant œdema, gonorrhœa (ophthalmia neonatorum, urethral and uterine gonorrhœa), diphtheria, syphilis, tuberculosis, tetanus (lock-jaw), leprosy, actinomycosis, amœbic abscess, trachoma (Egyptian ophthalmia), catarrhal conjunctivitis, blastomycetis, etc.

Non-specific suppurations are caused by a variety of microbes, among which the streptococcus pyogenes, and the several varieties of the staphylococcus, are principally concerned; less frequently are found the bacillus coli communis and the micrococcus tetragenus.

Boils, carbuncles, many pure and mixed cutaneous suppurations, and suppurations found elsewhere in the body, also come under this head. The guinea-worm discharges its embryos and also makes its own exit in a cutaneous suppuration which it excites.

In puerperal fever (child-bed fever), the infecting micro-organism is discharged in the *vaginal secretion*, or from such other suppurating foci as may be established during the illness. In scarlet fever, small-pox, typhoid fever, etc., when suppurations ensue, the discharges contain the infectious agents.

The principal communicable specific infectious diseases of the eye in which the specific micro-organisms are discharged in pus, are gonorrhœal ophthalmia, catarrhal conjunctivitis, diphtheritic conjunctivitis, and trachoma (Egyptian ophthalmia).

CHAPTER VII.

PORTALS OF ENTRY OF INFECTIOUS AGENTS AND OF PARASITES INTO THE BODY.

Microbes must observe a more regular manner of entering the body than leaving it, if they would produce disease. This is due to the fact that tissues differ in vulnerability to their attack, being favorable to the growth of some germs, and unfavorable to others. The same variation in susceptibility is noticed in the various organs of the body, and in different localities even where the tissues are not perceptibly dissimilar. From this is would appear that bacteria are preferential in their action, a conception that is quite generally believed. However, while admitting that infectious agents have a selective action, we must not overlook the part taken by the body in limiting microbic action through its secretions and anatomical peculiarities. Thus it is well established that the liver, through its secretions, has astonishing germicidal powers, and that to this influence we undoubtedly owe immunity from many infections. Again, the comparative freedom of the eye from infection is largely a result of winking, by which act mechanical removal of bacteria is accomplished. As a conse-

quence of the peculiarities just explained, a microbe cannot do harm if it enters the body unless it finds lodgment in a situation favorable to its growth. In other words, *the microbe and opportunity must meet for the production of disease.* Example: The tetanus (lock-jaw) bacillus is fatal if it enters a wound however trivial, yet it may be swallowed (indeed, often is) with impunity.

The portals of entry of infectious agents and parasites into the body may be included under the following heads:

1. Through wounds of skin and mucous membranes.
2. By the mouth or nose, through air.
3. By mouth, through food and water.
4. By genito-urinary tract.
5. By placenta (congenital infection).
6. Cryptogenic (unknown).

The immediately accessible portions of the body to infectious agents are either covered with skin or mucous membranes, so that in the production of disease, one of those surfaces must be penetrated.*

If an infection can be contracted either through wounds of the skin or mucous membranes, it is said to be *inoculable.* It is still a question in dispute whether

* To make this generalization clear it is only necessary to remind the reader that the air-passages have a mucous lining from their external openings down to their final terminations in air cells in the lungs; and that the alimentary tract is lined with an uninterrupted sheet of mucous membrane from inlet to outlet.

in this sense all infectious diseases are not inoculable, that is to say, whether the entrance of the agent does not depend upon some defect created in the integument or mucous membrane by another cause. Neither the nature of the infectious agent nor the region of the body which is the primary site of the disease enter into the discussion; nor is it disputed that penetration must occur; the question is, how does it happen, whether through the action of the bacteria themselves, or through the agency of another cause? If an accessory cause paves the way in all infections by interrupting the continuity of a surface, then all infectious diseases are inoculable. This latter belief, it will be recalled, is in entire accord with views previously expressed in the chapter on "The Phenomena of Infection," particularly in that portion which treats of the part the body plays in its production.

The lesions of entrance in some diseases are more palpable than they are in others, and in others again, they can never be found; yet that this latter fact is not a safe argument to use against the inoculability of a disease will be seen from a few illustrations. Take, for example, such a disease as yellow fever. Before the epochal work of the medical officers of the U. S. Army in Cuba, during 1898–99, yellow fever was regarded as a highly contagious disease, to guard against which it was deemed necessary not only to subject exposed individuals to the most rigid quarantine,

but also to fumigate clothing, bedding, and even letters, that had been in most casual contact with the sick. The measures enforced indicate that the causative agent was believed capable of gaining an entrance into the body without injury to the skin or mucous membranes. We now know, however, that a lesion of the skin inflicted by a mosquito is its only means of entrance (although we are yet in the dark as to the nature of the agent), and that, therefore, all former methods of prevention were futile in so far as control of the disease was concerned. Into such gross errors is it possible to fall when we apply methods of proven value in known to unknown diseases! Another case in point: Take typhoid fever; the typhoid bacillus enters the body by the mouth in food or drink. The most obvious lesions of the disease are seen in ulcers of the lymph nodes (glands) of the lower part of the small and the beginning of the large intestines. To affect these results the bacilli pass through the mucous membrane of the bowels, where they can be seen with the microscope in stained sections after death. The specific bacilli, however, do not stop in the sub-mucosa (sub-mucous tissue) but pass from here into the blood, where active growth and toxin formation is carried on. In other words, typhoid fever belongs to the bacteriæmias, a class of diseases characterized, as we have seen, by the presence of bacteria in the blood. Usually the more obvious symptoms of typhoid fever are those referable

to the bowels; but the intestinal features may be completely wanting, as has been repeatedly proven by post mortem examinations. Such cases are usually reported as "Typhoid fever without intestinal lesions." A study of typhoid fever, therefore, teaches that, while the agents of a disease may depend for entrance into the blood upon a gross or macroscopic lesion of a mucous membrane, *they also may enter through a non-demonstrable portal.* It might be asked at this point, "why do not the bacteria which get into the intestinal tract with food, and those which have their habitat there, often penetrate the mucosa and cause disease?" The answer to which would be, they do, far oftener than is generally supposed; in fact the intestinal tract is regarded as the chief portal of entry for many diseases for which no atria can be found (cryptogenic infections).

That some bacteria can enter certain tissues and attack certain localities more readily than others is admitted, because it has been experimentally proven. But between experiments, no matter how cunningly devised, and disease, as ordinarily contracted, there is a wide gap. When an animal or person is subjected to the germs of a disease, many million times the number of bacteria are applied than are ever present under natural conditions. Under such circumstances mere contact of these germs with the *right* mucous surface is sufficient to provoke disease. This is the case, for example, with the diphtheria bacillus, accidental infec-

tions with which having occurred in laboratories by a culture being unwittingly drawn up into the mouth. But under natural conditions of infection, where only casual contact between a patient and another person takes place, how can we believe that very many germs reach the throat through inhalation? Certainly they are by far not so numerous in air as when grown in cultures! Furthermore, in every disease, we concede the co-operation of contributing or predisposing causes: enlarged tonsils and adenoids in diphtheria; exposure and alcoholism in pneumonia; indigestion, fatigue, and over-ripe fruits, in cholera, etc. Why? if the germs acting alone are sufficient?

Finally, only a limited number of persons exposed to an infectious disease contract it, a fact which cannot be explained in the case of local diseases on grounds of greater general predisposition. In diphtheria, gonorrhœa, cholera, etc., might it not be because in those persons that we say are susceptible, the predisposing causes ultimately resolve themselves into invisible breaks or ruptures in the continuity of mucous surfaces?

The subject of the inoculability of diseases has been thus fully discussed because of our classification of the portals of entry. We have endeavored to show that our first group, "through wounds of skin or mucous membranes," might be made to include practically all diseases of known etiology. But such a division is

ill-suited to our purpose, which is to direct attention to the more obvious atria, and also to those portions of the body as are most likely to be the primary or initial seat of the various infections. Syphilis well illustrates our aim. Syphilis is a typical inoculable disease, a break in the integument or a mucous surface being required for entrance of the virus. But if we only treated of its portals of entry under lesions of the skin and mucous membranes, data of the highest importance would not be included. Nothing, for example, would be said of the fact that the initial infection is usually found upon the genitalia, not that the infection is hereditary. Hence, the reason for employing a classification apparently illogical.

The more obvious portals are those easiest remembered, and the most practical; and therefore, under the inoculable diseases are placed those which are either contracted through visible lesions, or *can* be inoculated, although under natural conditions this may not seem to occur;* and under the other divisions are grouped those which experience has taught attack one portion of the body rather than another. Obviously under such a classification, a disease will often be found under two or more heads.

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* Example:—Small-pox is ordinarily contracted by contact of an unvaccinated person with a patient or fomites. That it is directly inoculable, the earlier practice of variolation, introduced into England by Lady Mary Worthey Montague in 1727, shows.

SKIN AND MUCOUS MEMBRANES. The strictly inoculable infectious diseases are tetanus (lock-jaw), syphilis (acquired), lupus vulgaris (cutaneous tuberculosis), erysipelas, actinomycosis (cutaneous), glanders (farcy), leprosy (?), typhus fever, plague, anthrax (malignant pustule), hydrophobia, mountain fever (?), foot and mouth disease, malarial fever, yellow fever, filariasis (elephantiasis) blastomycetes, mycetoma (Madura foot), small-pox, and soft chancer.

Vegetable parasites are the cause of ring-worms of various parts (tinea tonsurans, tinea circinata), barber's itch (tinea sycosis), tinea versicolor, pinto (spotted sickness), yaws, and craw-craw. *Thrush* is a vegetable parasitic affection of the mucous membrane of the tongue and cheeks of infants.

Animal parasites which gain entrance through the skin are represented by the embryos of the uncinaria (parasite of hook-worm disease).

Parasitic insects of the skin are Sarcoptes scabiei (itch-mite); the head, body, and pubic louse; the larva of the horse bot-fly (*gastrophilus equi*), which causes "Creeping Eruption;" mosquitoes, which inoculate the agents of malaria, yellow fever and filariasis, and probably that of dengue; and the fly *glossina* which probably inoculates the parasites of trypanosomiasis (sleeping-sickness).

The mouth is a portal of entry for infectious agents

and parasites in both air and foods, and in the case of many diseases both methods of conveyance are possible. Yet because some diseases are nearly always, or even exclusively, contracted in one of these ways, it has seemed best to make a division of diseases into those inspired, and those taken in with foods and water. For example, neither Asiatic cholera nor dysentery are ever air-borne; nor is pneumonia contracted in either food or drink; yet in diphtheria, scarlet fever, small-pox, etc., both air and foods are fruitful sources of infection. The air, however, as a source of contagion, has been much exaggerated in the past, particularly where transmission of a disease over great distances has been laid at its door. With the exception of diseases conveyed by insects, such as mosquitoes, which may be blown by winds, there is really no readily communicable disease which is dangerous to others in the open air at a few yards distance. The fear that many persons have of passing a house where a contagious disease exists is without foundation. Carelessness within the house may be responsible for every room being dangerous—but that does not affect the air outside. When carefully investigated the so-called air-borne infections are discovered to have been carried by a third person, or by some article used and soiled in the sick-room. Usually it is the former. The truth is graphically presented by Dr. Rosenau who quotes Dr. J. H. White, "that infectious diseases are more often

conveyed from place to place in two shoes than in any other way." Therefore, air-borne, as applied to a disease, rather emphasizes the fact that the contagion enters by way of the respiratory passages, than that it is widely diffused in air.

MOUTH AND NOSE THROUGH AIR.
By the mouth and nose through air may enter the infectious agents in small-pox, chicken-pox, measles, scarlet fever, mumps, whooping-cough, pneumonia, tuberculosis, diphtheria, plague, anthrax, epidemic cerebro-spinal meningitis (?), rubella and influenza.

MOUTH THROUGH FOOD AND WATER.
A large number of the infectious and parasitic diseases are contracted exclusively by the pathogenic agents entering the body in foods and water. This method of infection is also by no means unusual in certain diseases for which the respiratory passages are the ordinary portals of entry. Foods and water, as a rule, offer excellent pabula for infectious agents and parasites, and are therefore quite frequently the means by which diseases are spread. The pollution of drinking-water by sewage, and the harm arising therefrom, has already been considered. Foods in relation to disease, however, requires some further elucidation; and while it is not our aim to take up all foods which serve as vehicles for infectious and parasitic agents, the manner of contamination of some of those consumed daily will serve to illustrate, in a general way, how these are a source of

disease. Furthermore, the movement of food-stuffs from one part of a country to another, or from one country to another, will be sufficiently dealt with to show the possibilities of diseases being literally picked up, carried hundreds of miles, and transplanted in regions where they previously did not exist.

Mention has been made of the manner in which typhoid fever, cholera, dysentery, etc., are contracted from drinking polluted water. Polluted water, however, although it may not be used for drinking purposes, may nevertheless be a source of danger from certain foods which grow in it and are consumed raw. This danger has been realized a number of times in the case of oysters and clams; and while water-cress has not yet been definitely incriminated, there is no reason why it may not be a menace to health in the same way.

Fruits and vegetables are sometimes polluted by the fertilizer, especially where human excrement is used to enrich the soil. In the United States this practice is not so common as in certain European countries, nor in the latter countries as in China, where it is the rule. But the number of Chinese truck-farmers in the United States and Cuba is not small, and steps should be taken to illegalize the use of human excrement for fertilizer unless it has been made innocuous by various approved methods. Only a few years ago, during the American occupation of Cuba, several Army Surgeons

made the filthy farming customs of the Chinese the sub-ject of special reports. It is scarcely necessary to mention the way human excrement used as fertilizer is dangerous, as it differs in no respect from fecal pollution of water; nor that the chief danger comes from vege-tables, berries, and salads which are eaten raw.

Pollution of berries, etc., may also come from the persons employed in gathering them. The people engaged in this kind of labor, while they are on the one hand drawn from the most densely ignorant and un-cleanest of foreigners, are on the other denied for weeks the most primitive accessories of civilization. Whole families, men, women, and children, in the early spring begin a migration which starts where the season opens soonest, and ends in the fall where it closes last. Dur-ing this, the warmest part of the year, they live in the fields in tents or covered wagons, working from sunrise to sunset with only such conveniences as their tempo-rary abiding-places afford. They ask very little in the way of comforts and get less. A bath to most of them is ordinarily obnoxious. From their bunks day after day they go to their work in the dawning morning, unwashed and uncombed, to return at night to sleep, too exhausted to make an effort to be clean. Relief from physiological emergencies is sought where they work, and quickly too—for the remuneration is "so much the measure." Sickness often prevails in these camps, typhoid fever, small-pox, scarlet fever, etc.,

and many workers harbor intestinal parasites. Need more be said of the probability of disease being served at our tables with fresh fruits and vegetables? Could the egg of a tape-worm find a more toothsome vehicle? And yet there are those who insist on eating berries unwashed because they lose a little flavor in the washing!

Some articles of food are more favorable to the growth of bacteria than others. *Milk is the best.* This is unfortunate, because, besides being a natural food for children and the greatest boon in sickness, it is next to bread the most-used article of diet. Because it furnishes such an excellent pabulum for bacteria, it is a frequent vehicle by which they are carried. Sickness in a milker, or in a dairyman's family, or the washing of milk-cans in polluted water, has time and again caused epidemics of scarlet fever, diphtheria, and typhoid fever, a fact which calls for the enactment of rigid laws regulating the production, handling, and sale of milk, and severe penalties for infractions of this law.

For a long time it has been the custom, when a few cases of typhoid fever occur in a community, to immediately impugn the character of the water-supply. This attitude of mind is a legacy of the time when polluted water was believed to be the only source of this infection. Where large numbers of cases occur, and especially if they are not limited to one neighborhood,

it is a wise precaution to suspect the drinking-water. But where cases are reported sporadically, especially in communities which have a municipal water system, it is more logical to seek the source elsewhere. The modern method of food distribution is a marvelous development, that is comparable to other inventions of the 19th Century. Through it perishable articles are not only distributed from one point where the supply exceeds the demand to others where they are needed; but they are also held, in the case of certain foods, a year or more—if the supply is too abundant. Nor is the distribution of such things limited to the farthermost boundaries of one country, but they are also shipped from one country to another across the widest seas. All this has come about through the expansion of the cold storage business, and the use of refrigerator cars, and cold storage plants on steam-ships. There is a large and ever increasing demand for various perishable articles of food out of season, so that there is a constant movement of supplies from one region to another. Furthermore, this demand has stimulated the speculative zeal of those engaged in the cold storage business, with the result that "in season" enormous storing of perishable foods is conducted. So great at these times is the demand for these commodities for storage, and for shipment to other parts of the country, that in many localities where they are grown it is impossible to purchase in the local market either fresh

fowl, eggs, milk, butter, fruits and game. Hence it is probably true, although we haven't the support of figures for the assertion, that more of the above mentioned foods are eaten out of season than in.

Our reason for dwelling upon this phase of modern economic life is to draw attention to the probability of communicable diseases being carried with foods from points widely separated, and the difficulty of tracing those so carried to their source. Refrigeration does not necessarily kill infectious agents and animal parasites, indeed, we have already called attention to the dangers of ice in relation to typhoid fever and cholera; so that through this system some contaminated article such as cream, may first be shipped five hundred miles to a creamery, churned into butter there, held in storage a few months, and finally be shipped another thousand miles, or across the ocean to Europe. The possible contamination of fruits, berries, and vegetables by those that pluck them has been considered a few lines above; in the refrigerator car, therefore, we see a way by which infectious or parasitic agents contaminating such products may be transported.

By the mouth through foods and water, are taken in the agents of typhoid fever, Asiatic cholera, small-pox, measles, scarlet fever, tuberculosis, diphtheria, plague, anthrax, syphilis, amœbic and bacillary dysentery, actinomycosis, milk sickness, and aphthous fever (foot and mouth disease).

PARASITES OR EGGS OF PARASITES. The following eggs, embryos, or parasites are taken into the body with foods or water: Eggs of beef tape-worm (*Tænia saginata*); eggs and larvæ of pork tape-worm (*tænia solium*); eggs of Tænia echinococcus (dog tape-worm), water; eggs of round worm (*ascaris lumbricoides*), water; eggs of pin-worm (Seat-worm, *Oxyuris vermicularis*), water; larvæ of Guinea-worm (*Dracunculus medinensis*), water; larvæ of trichinæ (Trichiniasis), pork; larvæ of Uncinaria (hook-worm disease), water and soil; worm of Strongyloides Intestinalis (endemic diarrhœa of hot countries), water (?); eggs of tricocephalus dispar; eggs of parasite causing Bilharziosis (Egyptian hæmaturia), (?); larvæ of common house-fly.

GENITO-URINARY TRACT. The commonest infectious diseases of the genito-urinary organs are the so-called "venereal diseases," gonorrhœa and syphilis. Both of these infections, however, may be found elsewhere upon the body in persons innocent of wrong-doing. In such cases the name of the disease is qualified by the word *insontium* written after it. In the female the vulva, vagina, urethra, and cervix of the uterus, are often the seat of gonorrhœa and syphilis, less often, of tuberculosis. Following abortion, or delivery at term, the uterus is frequently infected with the streptococcus of erysipelas, the colon bacillus (from feces), and the common mi-

crobes which cause suppuration. *Occasionally the external genitals are the seat of diphtheria.*

In the male, syphilitic and gonorrhœal lesions of the outside of the penis are common. The interior of the urethra is seldom affected by any other disease besides gonorrhœa. However, chancer (syphilis) of the inside of the urethra is sometimes encountered.

The bladder in both sexes is frequently the seat of inflammations (cystitis), the infection very often being carried into the bladder by catheterization. Besides getting into the bladder by way of the urethra, however, the infection may come from the blood by way of the kidneys. Tuberculosis of the bladder, a not uncommon infection, usually arises in this way.

ANIMAL PARASITES. The round worm has been found in the vagina.

CONGENITAL AND PLACENTAL INFECTION. Only one congenital disease occurs with any degree of frequency, namely, syphilis. Nevertheless, a child may be born with almost any of the infectious diseases if the mother is suffering at the time from the same. Thus, in the new-born has occurred typhoid fever, small-pox, scarlet fever, tuberculosis, etc. In the case of tuberculosis, however, it is surprising how *very rarely* the disease is found in the children of a consumptive mother; in fact congenital tuberculosis is so uncommon, that tuberculosis is not regarded by the profession as an hereditary disease.

The discharges from syphilitic lesions in the infant are highly dangerous to everyone who handles it except its mother. In such children sores of the mouth are common, and wet-nurses have frequently been known to contract the disease from suckling them.

CRYPTOGENIC. Cryptogenic infections refer to those deep-seated affections for which a portal of entry cannot be found. Endocarditis (inflammation of the heart valves), osteomyelitis (inflammation of bone), etc., are illustrations of this type of infection.

CHAPTER VIII.

PORTALS OF ENTRY AND AVENUES OF EXIT OF MICRO-ORGANISMS IN THE VARIOUS DISEASES.

Actinomycosis ("lumpy-jaw," "wooden tongue"); disease of man and domestic animals, particularly bovines.

(a) Cause: *Actinomyces bovis* (ray-fungus); *forms spores.*

(b) Localized: Lungs, bowels, subcutaneous tissues; often about jaw or tongue.

(c) Entry: Through mouth and nose with food; through wounds.

(d) Exit: Sputum, feces, and pus from lesions.

(e) Contracted: Doubtful whether can be communicated directly, either from animal to man, or from man to animal. Barley, oats, or rye, seem to be vehicles for the fungus.

(f) Disinfection: Since the actinomyces form spores, disinfecting agents are same as for anthrax and tetanus.

The ray-fungus can be seen with the naked eye in the pus and secretions of lesions as whitish or yellow-

ish bodies that have the appearance of fine grains of sulphur; seen best if a small quantity of the pus is pressed between two slides or watch crystals.

Anthrax (Wool-sorter's Disease, malignant pustule, splenic fever); disease of man and domestic animals, especially sheep and cattle.

(a) Cause: *Bacillus anthracis; forms spores.*

(b) Localization: Subcutaneous tissues (malignant pustule); lungs (wool-sorter's disease); intestinal tract; all of these lead to bacteriæmia (bacteria in blood) in vast majority of cases.

(c) Entry: Through wounds or abrasions; through mouth, eating meat or drinking milk of infected animals; through respiratory tract (inhaled in dust—wool-sorter's disease).

(d) Exit: Expectoration in pulmonic form; pus from abscess in local form; discharges from bowels in intestinal form.

(e) Contracted: By inhalation in sorting wool of infected animals; by abrasion or wound in handling flesh or hides of infected animals; by eating flesh or drinking milk of diseased animals; by the soiling of wounds or food-stuffs by infected flies.

(f) Disinfection and Prophylaxis: Forms spores, therefore unusual precautions are to be used. Burn cadavers, and contaminated

bedding, cloths, etc., where this is possible; where destruction is not feasible, use

(1) Super-heated steam (15 pounds pressure), 15 minutes.

(2) Tricresol, or lysol, 2 per cent solution, for two hours.

(3) Bichloride of mercury (1–500), for one hour.

(4) Formalin, 15 per cent solution, one and one-half hours.

(5) Boiling water, or steam, for two hours.

Bubonic Plague (la peste, black death, etc.).

(a) Cause: *Bacillus pestis;* non-sporogenous.

(b) Localized: Skin and subcutaneous tissues; lymph-glands; lungs; and intestinal tract.

(c) Entry: Wounds of skin; nose and mouth through air; mouth in food and water.

(d) Exit: In any of the discharges from situation where disease is localized; therefore, suppurations, suppurating buboes, abscesses, blisters, sputum, vomit, feces, urine.

(e) Contracted: By inhalation through contact with sick; through wounds contaminated or caused by infected fleas, flies, ants, etc., also food and water contaminated by the sick, or infected vermin, e.g., rats, mice, etc.

NOTE :—*Use all chemical disinfectants at or near the boiling point.*

(f) Disinfection: Must be thorough; bacillus not difficult to destroy; disinfect sputum, dejecta, urine, etc., with 5 per cent carbolic, 3–5 per cent formalin, 2 per cent tricresol, or boiling water the same as for other non-sporogenous bacteria. Wash body of patient, hands, and objects with 1–1000 bichloride of mercury. Fumigate with sulphur dioxide on account of its destructive action on vermin.

(g) Prophylaxis: Vermin, particularly rats and mice, are susceptible to plague; indeed, the former are believed to be the principle carriers of it. They infect the ground, dwellings, foods, and water. Therefore, safety lies in the destruction of all vermin in the houses. As dogs and cattle are also susceptible to the disease, they should be carefully protected from exposure. Screen dwelling and rooms; since the ground becomes infected by rats, and infected excreta, and because wounds of the feet and legs are frequent portals of entry for the specific bacillus, the constant wearing of shoes and leggins is a wise prophylactic.

The pneumonic form of plague is especially dangerous to attendants because the bacilli are thrown out in the spray in coughing and sneezing. Eat nothing

raw, such as milk, butter, cheese, etc.; serve everything hot. Eschew all fresh fruits and vegetables. Neither wash in, nor drink of, unboiled water. The bodies of those succumbing to the disease should be cremated. Clothing, sheets, etc., may be disinfected with solutions above given for sputum. Mop all surfaces in the sick-room frequently with a solution of bichloride of mercury (1–1000). Rigid isolation and quarantine should be instituted.

Epidemic Cerebro-spinal Meningitis.

(a) Cause: *Diplococcus intracellularis meningitidis;* non-sporulating.

(b) Localization: Membranes of brain and spinal cord.

(c) Entry: Probably nose by inhalation.

(d) Exit: Probably nasal secretions.

(e) Contracted: Does not seem directly contagious from sick to well, nor by fomites.

(f) Disinfection and Prophylaxis: Disinfect all secretions and discharges, and all objects that have been in contact with patient. Protect patient, and all articles that have been in contact with patient, from insects; therefore screen against flies, mosquitoes, etc.

Chicken-pox (varicella).

(a) Cause: Not known.

(b) Localization: Same as small-pox.

(c) Entry: Probably through respiratory tract (inhalation).

(d) Exit: Exhalations from lungs and skin, particularly in the dried scales of the latter; in all secretions and excretions, therefore, sputum, feces, urine, tears, nose, etc.

(e) Contracted: Highly contagious.

(f) Disinfection: Same as applied to small-pox.

(g) Prophylaxis: Same as in small-pox.

Cholera.

(a) Cause: *Spirillum choleræ Asiaticæ* (Koch), "comma bacillus;" non-sporogenous.

(b) Localization: Small and large intestines.

(c) Entry: Mouth in water and food.

(d) Exit: Discharges from bowels, sometimes in vomit.

(e) Contracted: Is usually water-borne infection, but may come from foods contaminated either by soiled hands, human fertilizer, or by insects which have been in contact with discharges containing the spirilla.

(f) Disinfection: Spirillum has slight resisting powers, 65° C. (149° F.) kills in five minutes, 100° C. (212° F.), destroying it at once; disinfect stools and vomited matter with 5 per cent solution formalin, 5 per cent solution carbolic acid, 2 per cent tricresol, or twice their

amount with milk of lime; treat bed-linen, etc., same as in typhoid; fumigation not necessary if appropriate sick-room precautions are taken.

(g) Prophylaxis: When cholera prevails, do not eat any fruits or vegetables raw; boil all water, whether used for drinking purposes or for washing of utensils; cook all foods well, and leave nothing exposed to the air, best to serve everything hot; protect sickroom, and all houses from flies, and keep free from insects. If these precautions are followed, one can live in a cholera infected town and nurse cholera patients without danger of contracting the disease.

Dengue (break-bone fever, dandy fever).

(a) Cause: Unknown.

(b) Entry and Exit: Not known.

(ç) Disinfection: Not practised, since as far as known it never proves fatal.

Diphtheria.

(a) Cause: *Bacillus diphtheriæ* (Klebs-Loeffler bacillus).

(b) Localization: All mucous membranes, usually tonsils, pharynx, and anterior and posterior nares; occurs in larynx, when it is called *membranous croup;* sometimes seen on the vulva; may infect wounds.

(c) Entry: By mouth and nose through air, or by mouth through contaminated foods or objects; only the air around the patient is dangerous, which is made infectious through coughing, sneezing, and careless disposal of secretions from infected portion; through wounds uncommon.

(d) Exit: Discharges from nose, mouth, pharynx and larynx; also from eye and vulva if disease situated there.

(e) Contracted: Is highly contagious, spread by contact with the sick chiefly, to a less extent through fomites; kissing, handkerchiefs, towels, toys, etc., may all convey the infection.

(f) Disinfection: Boiling water kills the diphtheria bacillus at once; direct sun-light is also effective in about an hour; disinfect sputum, nasal discharge, linens, utensils, etc., with boiling water, or with tricresol (2 per cent), formalin (5 per cent), carbolic acid (5 per cent); wipe all surfaces in room (including floor) with bichloride of mercury (1–1000) daily, fumigate with sulphur or formaldehyde.

(g) Prophylaxis: Isolation of sick, no matter how slight the infection, since there is no question that diphtheria is spread by the mild

or unsuspected cases; those in contact with the patient should use antiseptic gargle, disinfect hands, and avoid getting in the way of spray of expectoration; fumigate with sulphur or formaldehyde.

Amœbic Dysentery (chronic tropical dysentery).

(a) Cause: *Amœba dysenteriæ*, an animal parasite.

(b) Localization: Intestinal tract.

(c) Entry: Mouth through water, fresh fruits, and vegetables.

(d) Exit: Evacuations from bowels.

(e) Contracted: From infected water, etc.

(f) Disinfection: Only the stools need be disinfected, using the same solutions as in typhoid.

(g) Prophylaxis: Boil all water where the disease prevails.

Bacillary Dysentery (acute epidemic dysentery).

(a) Cause: *Bacillus dysenteriæ* (Shiga); non-sporogenous.

(b) Localization: Intestines.

(c) Entry: Mouth, through water and foods.

(d) Exit: In evacuations from the bowels; may be present in vomit.

(e) Contracted: Same as typhoid.

(f) Disinfection: As far as known only the stools have to be disinfected; the bacillus has about the same resisting qualities as the

typhoid bacillus, the strengths given for the various disinfectants in typhoid being sufficient.

(g) Prophylaxis: When the disease prevails boil all water and cook well all foods; eat neither fruits nor vegetables raw; use same precautions as in typhoid.

Erysipelas.

(a) Cause: *Streptococcus pyogenes;* does not form spores.

(b) Localization: Skin, or any wound that becomes infected with the micro-organism.

(c) Entry: Wounds or abrasions of skin and mucous membranes.

(d) Exit: In pus and secretions from the seat of the inflammation; also probably in the desquamating skin from an inflamed area.

(e) Contracted: Is highly contagious to any one with a wound; *to a woman about to be confined, or in the puerperium;* may be conveyed by fomites, instruments, etc.

(f) Disinfection: 100° C. (212° F.) moist, kills the streptococcus at once; all discharges should be disinfected with the solutions in the strengths recommended; urine should certainly be disinfected; room, patient, and bedding, clothing, etc., should be treated

as for small-pox; fumigate with formalde-
hyde or sulphur.

(g) Prophylaxis: Isolate the patient and his attendant;
latter should have nothing to do with opera-
tions, confinements, etc., during the period
of attendance on a case of erysipelas, and
for two weeks thereafter; during the lat-
ter period, daily disinfection of the hands,
hair, and person generally should be fol-
lowed; room where patient has been
should be thoroughly cleansed and dis-
infected.

Glanders.

(a) Cause: *Bacillus mallei;* is non-sporogenous.

(b) Localization: Exposed surfaces of the body
(farcy), or mucous membranes of the nose.

(c) Entry: Wounds of skin, or mucous membrane
of nose.

(d) Exit: Purulent discharges from nose; ulcers and
abscesses; expectoration; urine.

(e) Contracted: Usually by contact with diseased an-
imals (horses and asses), or hides of same
through abrasions of skin.

(f) Disinfection: Easily destroyed by boiling, or the
usual strengths of carbolic acid, formalin,
or tricresol.

(g) Prophylaxis: Consists in the destruction of all

diseased animals, and thorough disinfection of the discharges and soiled dressings of infected individuals.

Gonorrhœa.

(a) Cause: *Micrococcus gonorrhœœ* (Neisser); non-sporogenous.

(b) Localized: Urethra (gonorrhœa, specific urethritis, clap); eye (gonorrhœal ophthalmia, ophthalmia neonatorum); vagina; blood; joints; etc.

(c) Entry: Urethra, eye, vagina, occasionally wounds.

(d) Exit: In suppurations from diseased tissues or organs.

(e) Contracted: In urethra and vagina from irregular intercourse; in eyes of adults from polluted fingers or towels, etc.; in new-born during birth; in female children the vagina is infected through soiled sponges, wash-cloths, etc.

(f) Disinfection: Micro-organism has slight resistance; boiling kills it at once. Ordinary disinfectants effective in the percentages in which used for vegetative forms of other bacteria.

(g) Prophylaxis: Males with acute or chronic gonorrhœa (gleet) should not marry until

cured.   Individuals with the disease should be warned of the awful danger consequent upon eye infection.   The children born of immoral mothers, and all born among the lowest classes, should have instilled into each eye immediately after birth one to two drops of a 1 per cent solution of nitrate of silver.

Hydrophobia (Rabies, Lyssa).

(a) Cause: Unknown.

(b) Localized: Wounds, primarily; secondarily, brain and spinal cord.

(c) Entry: Through wounds.

(d) Exit: Saliva.

(e) Contracted: Through bite of mad animal, such as dog, wolf, cat, etc. Novi says, "that midges and flies are capable of conveying the infection."

(f) Disinfection: Saliva, and linens, beddings, etc., soiled by saliva, should be boiled, or disinfected with one of the solutions advised for other diseases.

(g) Prophylaxis: Kill all mad animals, and all others bitten by same.   Dogs should be muzzled. Bites of all animals should be carefully washed and thoroughly cauterized with concentrated carbolic acid, or a glowing

poker. Previously, oral suction may be practised. Keep wound open for from five to six weeks.

Influenza (La Grippe, Russian fever).

(a) Cause: *Bacterium influenzæ;* is non-sporogenous.

(b) Localized: Throat; nose; lungs; blood.

(c) Entry: By air through mouth and nose.

(d) Exit: Discharges from nose, throat, and lungs.

(e) Contracted: Probably entirely by contact with the sick.

(f) Disinfection: Bacilli are quickly destroyed by even weak solutions of the ordinary disinfectants; at once by boiling; fumigate with formaldehyde or sulphur.

(g) Prophylaxis: Since influenza is a serious disease in the case of the very young and the aged, and furnishes a large proportion of the mortality at these periods of life, the nasal and bronchial secretions should be carefully disinfected in every case.

Leprosy.

(a) Cause: *Bacillus lepræ;* non-sporogenous.

(b) Localized: Mucous membranes and skin generally; nervous system.

(d) Exit: In suppurations from broken-down nodules of nose, mouth and skin.

(e) Contracted: Contracted with difficulty. Long,

intimate contact seems essential. Attendants need have no fear of contracting the disease, if reasonable precautions are taken.

(f) Disinfection: Not known, since germ has never been cultivated outside the body; probably same as for tuberculosis.

(g) Prophylaxis: Cleanliness; disinfection of discharges from suppurations and soiled linens, etc.; segregation of lepers.

Madura Foot (mycetoma, Madura disease, pied de Madura).

(a) Cause: Streptothrix maduræ, forms spores (?).

(b) Localization: Usually feet, but may affect other portions of body.

(c) Entry: Through wounds in skin.

(d) Exit: In discharges from broken-down nodules.

(e) Contracted: In countries where the disease is common, is attributed to prick of a thorn; is probably not communicated from man to man.

(f) Disinfection: Should be same as for anthrax and tetanus.

Malarial Fever (ague, intermittent fever).

(a) Cause: *Hæmatozoa malariæ* (sporozoa).

(b) Localized: In blood and tissues.

(c) Entry: Only through bites of mosquitoes.

(d) Exit: In the blood solely through bites of mosquitoes.

(e) Contracted: By being bitten by that species of mosquito (Anopheles) which acts as host for the parasite.

(f) Disinfection: Consists in the destruction of mosquitoes by an insecticide in the bed-room of the sick. Pyrethrum, two pounds to each one thousand cubic feet. Sulphur, one pound to each two thousand cubic feet. Where sulphur used, two hours' exposure sufficient, and moisture (which decolorizes and destroys fabrics) not necessary. As pyrethrum only stuns the knats they must be gathered up and burned after fumigating.

(g) Prophylaxis: Where malaria is prevalent, screen rooms and houses with fine mesh screens to keep mosquitoes out; chief danger is at night, since anopheles is nocturnal in its habits. Anopheles breeds in shallow puddles and ditches, in which places the young can be destroyed by sprinkling surface of water with coal-oil about every two weeks. Two grains of quinine three times daily is also a wise precaution.

Measles.

(a) Cause: Unknown.

(b) Localization: Eyes, nose, mouth, throat, and skin.

(c) Entry: Probably air borne to mouth or nose.

(d) Exit: Oculo-nasal secretions, saliva, breath and desquamated skin.

(e) Contracted: By contact with sick through air; fomites; third person.

(f) Disinfection; Same as for small-pox.

(g) Prophylaxis: Same as for small-pox.

Mumps (epidemic parotitis).

(a) Cause: Unknown.

(b) Localized: One or both parotid glands.

(c) Entry: Probably mouth.

(d) Exit: Supposedly, in saliva.

(e) Disinfection and Prophylaxis: Only sputum need be disinfected; however, because in the army the efficiency is severely taxed by the orchitis which so commonly occurs with mumps in adults, isolation and disinfection as for other contagious diseases should be practised.

Pneumonia (Lobar pneumonia).

(a) Cause: *Diplococcus pneumoniæ* (pneumococcus, micrococcus lanceolatus); is non-sporogenous.

(b) Localization: Lungs; by extension, in blood, pleural cavity and pericardium.

(c) Entry: Respiratory channels; normally present in almost everyone's mouth.

(d) Exit: Sputum; in discharges when empyema (secondary to pneumonia) ruptures, or is opened by operation; in complications, otitis media, etc.

(e) Contracted: Exposure to cold and wet; exposure to pneumonia while fatigued and depressed.

(f) Disinfection: Easily destroyed by boiling; carbolic acid 3-5 per cent, formalin 3-5 per cent, tricresol 1 per cent. Sulphur or formaldehyde fumigation.

(g) Prophylaxis: January, February, and March, are the coldest and most disagreeable months in the year and are on this account the months in which the greatest number of cases of pneumonia occur. Avoid wetting and exposure, and especially after "catching cold." Intoxicated persons are particularly susceptible to pneumonia, as are also infants, old people, and those debilitated by a chronic disease. Mental depression is also a predisposing cause.

Relapsing Fever ("Famine fever," seven-day fever, etc.).

(a) Cause: *Spirochæta Obermeieri*.

(b) Localization: Blood.

(c) Entry: Not known, probably through bite of insect, e.g., bed-bug.

(d) Exit: Probably through bite of suctorial insect.

(e) Contracted: Seems to be contagious; but as only seen where over-crowding, and where hygienic conditions are bad, probably conveyed by insect.

(f) Disinfection: Nothing known of the micro-organism outside of the body.

(g) Prophylaxis: Plenty of fresh air, good food, and personal cleanliness, are probably the best means of avoiding the infection. Screen houses against mosquitoes, flies, etc., and wage war against all vermin such as bed-bugs, roaches, etc.

Rubella (Rotheln, German measles).

(a) Cause: Not known.

(b) Localization: Blood, skin, respiratory tract.

(c) Entry: Probably through respiratory tract.

(d) Exit: Respiratory tract and probably emanations from skin.

(e) Contracted: Resembles measles (which see).

Scarlet Fever.

(a) Cause: Not known.

(b) Localized: Throat; blood; skin; in complicating suppurations, e.g., ear.

(c) Entry: Respiratory tract; also wounds.

(d) Exit: Sputum; nasal secretions; skin, before and during exfoliation; suppurations during and following the disease.

(e) Contracted: Contact with the disease, or with persons and objects which have been in contact with same; from milk handled by persons sick or convalescent from scarlatina; from individuals with suppurations consequent upon an attack, e.g., otitis media (middle-ear disease).

(f) Disinfection: Virus has unusual vitality; disinfect same as for small-pox or diphtheria.

(g) Prophylaxis: Quarantine should not be less than forty days after the completion of desquamation, and it might even be continued longer; air-passages should be treated antiseptically during whole period of quarantine. Discharging ear is infectious, and children with such a discharge have been known to transmit the disease in this way. Sun and air room some weeks after case. Most rigid quarantine and disinfection must be practised to prevent contagion.

Small-pox (variola).

(a) Cause: Not known.

(b) Localization: Skin, conjunctivæ, mouth, œsopha-

gus, rectum, and probably blood; is general infection.

(c) Entry: Probably through respiratory tract; may also enter through abrasions, as the former practice of variolation proves.

(d) Exit: Exhalations from lungs and skin, particularly in the dried scales of the latter; in all secretions and excretions, therefore in sputum, urine, feces, tears, pustules, etc.

(e) Contracted: Highly contagious; virus is in air surrounding patient, being thrown off with breath and wafted from eruption; is conveyed by persons and fomites; may also be conveyed by flies.

(f) Disinfection: Disinfect everything which has been in contact with patient; also entire room and contents. Screen windows from flies, and kill all vermin; wipe all surfaces of room daily with bichloride of mercury (1–1000); linens, etc., boil, steam, or immerse in tricresol (2 per cent), formalin (5 per cent), carbolic acid (5 per cent); anoint patient with carbolated vaselin; all abscesses and ulcers should be regarded as infectious until healed; fumigate after recovery with sulphur or formaldehyde.

(g) Prophylaxis: Vaccination of every one during

an epidemic, whether previously vaccinated or not; isolation of sick, and disinfection of patient and room after recovery.

Epidemic Stomatitis (aphthous fever, foot and mouth disease); is disease of cattle, sheep, and pigs, which is often transmitted to man.

(a) Cause: Unknown.

(b) Localization: Mucous membrane of mouth and lips; also in wounds; in cattle also on tits and udder.

(c) Entry: Mouth through milk, and wounds of hands, arm, and fore-arm from infected animal.

(d) Exit: From secretions of mouth, and ulcers of the disease.

(e) Contracted: Contracted from pustules of sick animal, or from milk, butter and cheese.

(f) Disinfection: Disinfect secretions from mouth, also discharges from the lesions of the disease, bandages, linens, etc., in the usual strengths of the solutions given for other diseases.

(g) Prophylaxis: Where epidemic in cattle, boil all milk, and isolate all sick cattle; also individuals who take care of them; butter and cheese made from milk of infected animals can also convey the disease.

Syphilis (Lues).

(a) Cause: *Spirochæta pallidæ* (?).

(b) Localization: Practically everywhere in second and third stages; in first stage (primary) the initial lesion (chancer) is usually upon the genitals; extra-genital chancers, however, may be found upon any cutaneous surface; also upon lips, tongue, tonsils, eye-lids, or rectum.

(c) Entry: Through abrasions of skin or mucous membrane; through spermatozoan; through ovum; placenta.

(d) Exit: From discharging lesions, and with blood when drawn.

(e) Contracted: Usually through illicit intercourse, when primary lesion is found upon genital organs; may be innocently contracted through kissing, from infected handkerchiefs, pipes, dishes, etc.; by pricking finger during operation upon a syphilitic, or through examination during confinement. When innocently contracted is called syphilis *insontium* to distinguish it from venereal syphilis, which carries with it an implied stigma.

(f) Disinfection: Boiling water or steam; usual chemical disinfectants.

(g) Prophylaxis: Abstinence from irregular relations;

physicians should impress upon all syphil-
itics the danger to others of contracting
the disease from discharges from both the
primary (chancer) and secondary (mucous
patches, ulcers, particularly of throat)
lesions.

Tetanus (Lock-jaw).

(a) Cause: *Bacillus tetani; forms spores.*

(b) Localized: Subcutaneous or sub-mucous tissues;
usually former; umbilical cord of new-
born.

(c) Entry: Wounds, often of trifling nature; also in
wounds where much tearing of tissue
has occurred, especially if soiled with
earth; compound fractures.

(d) Exit: In discharges from wound only.

(e) Contracted: Gun-shot or cannon-cracker wounds;
contusions in which powder, earth or other
foreign bodies driven into tissues; punc-
tured wounds of hands or feet, e.g., by
nail.

(f) Disinfection: As forms spores, prolonged boiling
or contact with powerful disinfectants
necessary, tricresol or lysol 2 per cent solu-
tion, two hours; bichloride of mercury
1–500, two hours. *Use solutions hot.*
Only discharges from wound, and soiled

dressings, need be disinfected. See anthrax (p. 185).

(g) Prophylaxis: Consists in thorough opening and cleansing of all wounds which have been soiled with earth, or resulted from Fourth of July celebrations; or in which foreign body is imbedded in flesh. Where tetanus is feared, the wound should not be sealed with dressings, but left exposed to the air; *tetanus antitoxin should be used.*

Tuberculosis.

(a) Cause: *Bacillus tuberculosis* (Koch bacillus); non-sporogenous, but *exhibits greater resistance to destructive agencies than vegetative forms of other bacteria.*

(b) Localized: Practically everywhere; lungs (phthisis, consumption); lymph glands (scrofula); bones, abdominal viscera; brain, etc.

(c) Entry: Chiefly by air-passages, and by mouth with food and drink; also through wound of skin and mucous membranes.

(d) Exit: In all discharges from diseased tissues or organs. As lungs most frequently are the seat of the disease, the sputum is the most common vehicle of discharge.

(e) Contracted: Usually by inhalation where prolonged contact with consumptive; probable

that infants occasionally contract the disease by drinking milk from tuberculous cows.

(f) Disinfection: Boil infected material in closed vessel ten minutes or longer; well to burn objects of no value. For sputum, formalin 15–20 per cent, tricresol 2 per cent, lysol 2 per cent are recommended; mix these thorougly with sputum and let stand one hour. Fumigate with sulphur or formaldehyde.

(g) Prophylaxis: Chief danger is from carelessness of the consumptive in disposal of sputum; if careful disinfection of expectoration and all things soiled during the act of sneezing, coughing, etc., is practised, he is no menace to others. Those immediately surrounding the consumptive most often fall victims, a fact better established than heredity in this disease. Neither milk nor meat from tuberculous cattle should be used. Consumptives should refrain from kissing others; nor should they marry.

Typhoid Fever.

(a) Cause: *Bacillus typhosus;* is non-sporogenous.

(b) Localization: Primarily in intestinal tract or lungs; in blood; bladder; in complicating suppurations.

(c) Entry: By mouth, through water principally; less often in ice, milk, and other foods; in some localities oysters are especially dangerous when eaten raw.

(d) Exit: Discharges from bowels; urine; sputum; suppurative complications; skin; in rose-spots; sometimes in vomit.

(e) Contracted: The specific bacillus must get into the mouth and be swallowed; great care must be exercised by those in attendance upon typhoid fever patients not to contaminate their foods, or the foods of others.

(f) Disinfection: The bacillus is killed immediately by boiling water or steam; disinfect the sputum, the stools, discharges from the bowels, urine, linens, eating-utensils, etc., by boiling, or by 5 per cent carbolic acid, 5 per cent formalin, 2 per cent tricresol, *and let stand one hour;* bichloride of mercury (1–1000) may be used to disinfect the urine. When convalescence established, wash out bladder once daily for several days with bichloride of mercury (1–20,-000), or give urotropin 30 to 60 gr. daily for the same length of time; all discharges should be received in vessels containing a small quantity of one of the disinfecting solutions, after which the balance

is added in sufficient quantity to make up
the strength recommended.

(g) Prophylaxis: Wherever human excrement is used
as fertilizer, eat nothing raw; boil all
water whether used for drinking purposes
or for dish-washing, unless the water-
supply is above suspicion; boil the milk
and water whenever typhoid prevails, and
use no ice in water for drinking purposes;
screen house against flies.

The essential thing in prophylaxis in typhoid fever,
in fact, in all communicable diseases, is to see to
thorough disinfection of all infectious discharges in the
sick-room. If the latter were done, epidemics of com-
municable diseases could easily be controlled. The fol-
lowing directions, as given by Prof. Osler, are the pre-
cautions followed in the Johns Hopkins Hospital to
guard against the spread of typhoid fever: "Dishes
must be isolated, washed, and dried separately, and
boiled daily. Thermometers must be isolated, kept
in bichloride of mercury (1–1000), which must be re-
newed daily. Linen, when soiled, must be soaked in
carbolic acid (1–20), for two hours before sending to
the laundry. Stools must be thoroughly mixed with
an equal amount of milk of lime, and allowed to stand
one hour. Urine must be mixed with an equal amount
of carbolic (1–20), and allowed to stand one hour. Bed-
pans and urinals must be isolated and scalded after

each time of using. Syringes and rectal tubes must be isolated and the latter boiled after using. Tubs should be scrubbed daily and soaked in carbolic as the linen is. Hands must be scrubbed and disinfected after giving tubs or working over typhoid fever patients. Blankets, mattresses, and pillows must be sterilized after use, in the steam sterilizer."

Whooping-cough (Pertussis).

(a) Cause: Unknown.

(b) Localization: Respiratory tract.

(c) Entry: Nose and mouth through air.

(d) Exit: Secretions from nose and mouth.

(e) Contracted: From the sick, or from room, handkerchief, etc., infected by same.

(f) Disinfection: As cause not known, no data. However, boiling water or steam, and the usual strengths of the chemical disinfectants are recommended. Fumigate with sulphur or formaldehyde.

Yellow Fever.

(a) Cause: Not known; mosquito (*stegomyia fasciata*) known to carry the virus.

(b) Localization: Blood.

(c) Entry: Bites of stegomyia mosquitoes.

(d) Exit: Through bites of mosquitoes.

(e) Contracted: Only by being bitten by infected mosquitoes.

(f) Disinfection: Only necessary to destroy all mosquitoes in sick-room and house. Sulphur or pyrethrum two pounds to every one thousand cubic feet of space, exposure two hours.

(g) Prophylaxis: Protect sick from bites of mosquitoes; screen houses, use mosquito nets, and destroy mosquitoes in house by burning sulphur or pyrethrum; in yellow fever zones, the breeding places of mosquitoes should be removed or drained; persons while out, should protect themselves from bites.

CHAPTER IX.

DISINFECTION AND DISINFECTANTS.*

The purpose of disinfection is to prevent the spread of the communicable diseases. In its application it aims at the destruction of those minute forms of animal and vegetable life which prey upon both man and animals and cause disease. The discovery of the relationship between living pathogenic agents and disease; of the manner in which these same agents enter and leave the body; and the subsequent determination of reliable methods of destroying them, marked a new epoch in the history of medicine in so far that disinfection was for the first time placed upon a secure foundation. As a result, before the unseen terrors of the air and water we no longer wring our hands in abject and helpless misery while thousands of our fellow-beings are smitten by disease! Nor do we inhumanly flee from those afflicted, leaving them not only to the mercy of a cruel sickness, but also to those beasts among

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*For most of the data in this chapter and much in the preceding, the author has drawn freely upon Dr. Rosenau's "Disinfection and Disinfectants," an incomparable book on the subject; to a lesser extent upon Dr. Sternberg's "Lomb Prize Essay." To both authors he gratefully acknowledges his indebtedness.

humanity who see in calamities only opportunity for license and profit!* But with a courage born of knowledge, and with the consciousness of power which the former inspires, we fight a scourge as we would a ruthless foe.

The weapons used against infectious diseases are disinfectants and insecticides, weapons which in our own generation have made in civilized communities "plagues" impossible. Indeed, were it not for the indifference displayed by the public towards sanitary science in not providing its health officers with ample resources and authority, many prevailing infectious diseases, such as tuberculosis, typhoid fever, etc., would be far less common, and would year by year claim fewer victims, until they too would in time come to be spoken of as belonging to the horrors of another age.

Often, in omitting the enforcement of sanitary measures, physicians and nurses seem callous to the public weal, a negligence due no doubt to lack of encouragement from the patient's family. Yet who are in better positions to dam at their source the springs of disease? In every infection the patient is an incubator, as it were, for pathogenic microbes, which leave his body by definite channels in the excretions and secretions. If these discharges are not immediately made innocuous, there is the probability that the infection will be spread. The task of disinfecting any

*See Walter Reed and Yellow Fever, by H. A. Kelly.

dangerous discharge at the bed-side is comparatively easy, and one which is properly a duty that the physician should direct, and which the nurse or family should perform; and were this duty, which is one to humanity, always conscientiously discharged, foods and drinks would not be polluted in the manner described in previous pages.

The importance of careful disinfection in the sick-room of all infectious secretions and excretions, of bed-linen, towels, eating-utensils, flat surfaces, etc., is quite well understood by the public generally, and is treated at length in text-books familiar to both physicians and nurses. Nor do the descriptions of the various disinfectants and their use differ so greatly as to require special mention. The following brief outline is intended solely to call attention to the most efficient disinfectants, and to the strengths of the chemical disinfecting solutions commonly employed.

HEAT.   Heat, as has been stated elsewhere, is the most reliable disinfectant known. Burning, or heating objects to incandescence, renders them sterile. However, this kind of disinfection, it is obvious, is seldom practicable, and we must fall back upon lower temperatures. Either dry or moist heat is then available. Other things equal, moist heat is a far more efficient destroyer of germ life than dry heat, because it has greater powers of penetration. Boiling tubercle bacilli in water ($212°$ F., $100°$ C.) for ten

minutes kills them, whereas they can resist a dry heat of 212° F. for several hours.   More efficient than boiling is live steam, especially if it is used under a pressure of from one to three atmospheres.   Special apparatuses called *auto-claves*, are used for this purpose, and all important sanitary stations possess such an equipment.

The advantages of using an apparatus in which steam under pressure can be employed are three-fold: (1) The penetrating power of the steam is increased; (2) since the temperature of steam rises with the pressure, its germicidal power is accordingly enhanced; (3) on account of the higher temperature and greater penetration, the time required for disinfection is greatly diminished. As a matter of fact, the bulkiness of some articles, such as mattresses, bales of rags, etc., practically precludes disinfection without the use of auto-claves or especially devised disinfecting chambers.

Besides steam, formaldehyde alone, or in combination with steam, is used under pressure for disinfection. Applied together in this way the two are more quickly germicidal than either gas used alone.

Bacteria differ in regard to the temperature required to kill them.   Almost all the vegetative forms are killed at a temperature of (60° C., 140° F.) if applied for ten minutes, and boiling (100° C., 212° F.) destroys the same at once.   An exception to this rule, as we have elsewhere pointed out, is the tubercle bacillus, which,

although only occurring in a vegetative form, can withstand the temperature of boiling water (212° F., 100° C.) for ten minutes. In practical work, boiling, where possible, is resorted to for all vegetative forms of bacteria, the length of time depending upon the mass of material to be disinfected.

Spores of bacteria are quite difficult to kill. Where the apparatus is at hand, steam under a pressure of from twenty to twenty-five pounds (temperature 230° F., 105° C.—240° F., 115.5° C.) is used. If steam under pressure is not available, boiling for an hour in a closed
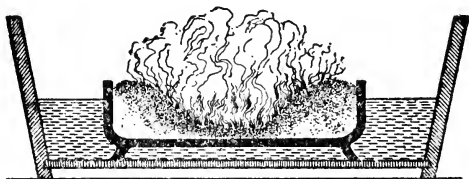
Fig. 26.—The Pot Method of Burning Sulphur.   (Rosenau.)

vessel is a safe rule. Fortunately, none of the epidemic diseases is caused by a spore-forming microbe, a fact which lightens greatly the burden and responsibility imposed upon the disinfector.

GASEOUS DISINFECTANTS. Two gaseous disinfectants are in common use throughout the world, formaldehyde and sulphur dioxide. Of these, formaldehyde approaches more nearly our conception of an ideal disinfectant than does sulphur dioxide

or any other.   Compared with sulphur dioxide, formaldehyde has these distinct advantages, namely, it is non-poisonous, is a true deodorant, and does not attack metals, colors, or fabrics.   On the other hand, it does not destroy vermin, as does sulphur, a disadvantage that is disappointing in the light of what recent investigations have taught us of the highly important part which various insects play in the conveyance of disease. To obtain the best results with both formaldehyde and sulphur requires a full knowledge of the conditions under which they are generated, of the apparatuses used in disinfection, and of such concomitant arrangements of rooms, buildings, conditions of temperature and moisture, etc., as are necessary.   It is not the intent of this chapter, however, to enter into the subject of disinfection so extensively as such a description would entail.

CHEMICAL DISINFECTANTS (liquid).   Liquid disinfectants are unequivocally superior to gaseous ones if direct contact by washing, immersion, or mixing, of the disinfectant and infectious matter can be accomplished.   Gases cannot be depended on for more than surface disinfection, a fact which restricts their use to the inaccessible parts of rooms, buildings, ships, etc., and to works of art, e.g., paintings, and fine fabrics.

The resistance of infectious agents to chemical disinfectants is subject to the same variations as their

resistance to heat.   Such vegetative forms of bacteria as are more resistant to heat, are more resistant to chemicals; and the sporulating forms are even more difficult to kill with chemicals than with steam under pressure. Chemical disinfectants vary greatly in the strength of each required to be efficient, and their disinfecting powers also vary with the material to be disinfected. Very powerful disinfectants may fail to act on account of chemical union taking place between them and the material in which the infectious agents are contained. Thus both bichloride of mercury and carbolic acid lose much of their disinfecting qualities when added to albuminous material, on account of the formation of an insoluble albuminate which is inert.   Furthermore, if one of these substances be used in excess in the belief that the above defect may be overcome, the end is just as likely not to be realized, because this insoluble combination surrounds the infectious agents and prevents contact between them and the disinfectants. In instances of this kind either the chloride of lime, the cresols, or formalin are to be preferred.   Where the medium contains much organic matter or filth, even where the proper disinfectant is used, much stronger solutions than commonly employed are advisable.   An extremely valuable point to remember in applying any of the chemical disinfectants is that the disinfecting power of all of them is greatly enhanced if they are heated with the material to be disinfected; and the

higher the temperature, the more is their disinfecting power increased.   In this way substances of feeble disinfecting powers may often be used to advantage.   The value of heating a disinfectant is well illustrated by comparing the action of carbolic acid upon the anthrax bacillus and its spores.   Anthrax bacilli are killed in ten seconds by a one per cent solution of carbolic acid, yet its spores can live a month in a five per cent solution.   But if the temperature of a five per cent solution of the same acid is raised to 75° C. (134.6° F.), they are killed in three minutes.   *In all disinfection*, therefore, *hot solutions should be used*.

DISINFECTING SOLUTIONS.

Perhaps the commonest disinfectant used Bichloride is bichloride of mercury (corrosive subli- of Mercury. mate).   It is a powerful germicide, even in weak solutions.   It has several serious drawbacks, however, which limit its usefulness; among these is the fact that it is a corrosive poison; that its solutions attack practically every metal; and that it unites with albuminous matter.   For the last reason it is not to be used as a disinfectant for the disinfection of sputum, feces, and discharges containing albumin, such as pus.   For washing floors, walls, and other surfaces, a hot solution (1–1000) is as efficient as any other disinfectant.   For ordinary purposes the 1–1000 solution is the strength employed.   This can be prepared

from the tablets when a small quantity is desired, or in
larger quantity by taking

> Bichloride ....grs. 61½.
> Citric acid or common salt.........grs. 61½.
> Water.......................gallon 1.

The 1–1000 solution is ample for the destruction of all
non-spore-bearing bacteria at ordinary temperatures
in one-half hour.   For spores, stronger solutions (1–500),
and a longer exposure (one hour), are advisable.   As a
disinfectant for the hands in surgical work, and as a
moist dressing in various inflammatory conditions, this
solution of mercury is in constant use.

FORMALIN.   Formalin is used as a disinfectant in a 4 to
5 per cent solution of the 40 per cent solu-
tion of the gas in water.   Its advantages as
a disinfectant are many; it does not injure most fabrics;
it attacks only two metals, iron and steel, and these
only when hot.   It is non-poisonous, and albuminous
matter does not interfere with its action.   It kills spores.
It is a true and efficient deodorant.   Urine, feces,
sputum, and all albuminous discharges, are quickly
disinfected and deodorized by it.

CARBOLIC
ACID (phenol).   Carbolic acid is a useful disinfectant and
is with reason widely used.   A 3 to 5 per
cent solution (the latter 1–20) is the
strength employed.   Since it does not
kill spores, it should not be used after anthrax, tetanus,

malignant œdema, and other diseases due to bacteria which produce spores. Although it coagulates albuminous matter, it is not so active in this respect as bichloride of mercury, and can therefore be used for the disinfection of soiled linens, clothing, and also for excreta. It is well to remember that carbolic acid is a powerful corrosive poison. For liquid discharges in cholera, typhoid, dysentery, etc., a 5 per cent solution may be used, when twice the amount of carbolic to material is advised. The mixture should be allowed to stand four hours.

A convenient method of preparing a five per cent solution (1–20) is as follows:

Carbolic acid (95 per cent)..........ozs. 6¼
Water ....gallon 1
Agitate until the acid is thoroughly dissolved in the water.

TRICRESOL.   The cresols are among the most powerful and valuable disinfectants known. None of them are as poisonous as carbolic acid (phenol), nor are they open to the objection that albuminous material interferes with their action. *They all kill spores.* Tricresol may be used in 1 per cent solution for the disinfection of infected discharges of all kinds. The other preparations of the cresols, *solutol, solveol, lysol,* as compared to tricresol, have a reputation for disinfecting power in the order in which they are named.

LIME. Lime (quicklime), as such, is useful for the disinfection of cadavers dead of infectious diseases. For this purpose twice the weight of the body in unslaked lime is packed about the cadaver, which should be contained in a tight coffin. Neither water or moisture need be added.

MILK OF LIME. Which is prepared from the slaked lime (hydrate of lime, calcium hydrate) by adding one part by weight of hydrate of lime to eight parts of water, is a valuable disinfectant for excreta.

The slaked lime used in the preparation should always be freshly made by mixing one pint of water to two pounds of lime. For the disinfection of stools, an amount of milk of lime equal to the material to be disinfected should be used, and the mixture be allowed to stand two hours. Whitewash is slaked lime mixed with water to the consistency of a thick cream. It is a valuable means of disinfecting the walls and ceiling of stables, cellars, and other rough structures.

"CHLORIDE OF LIME." Chlorinated lime is best adapted for the disinfection of excreta and sputum. It is both deodorant and disinfectant. For disinfecting purposes dissolve eight ounces of the chloride of lime in a gallon of water (Sternberg). This solution should be placed in the vessel before it receives the discharge. From one to two quarts are used in the case of cholera or typhoid stools. After

thorough agitation, the mixture is allowed to stand from one-half to one hour. For sputum, an amount equal to the volume of the sputum should be added, or the sputum cup should be filled about one-half with the solution before use. Chlorinated lime cannot be used for the disinfection of fabrics or colored goods, since it bleaches and attacks the fabric directly. The chlorinated lime used in the preparation of disinfecting solutions must have been contained in an air-tight receptacle, otherwise from exposure to the air much of its disinfecting powers are lost. It has about the same germicidal value as milk of lime.

CHAPTER X.

THE COLLECTION AND EXAMINATION OF SECRETIONS AND EXCRETIONS.

This chapter in introduced as an aid in the examination and collection of specimens of the various excretions, in preserving them from deterioration, and in describing them in simple terms according to professional custom. Attention is directed only to such points as may be of value either to the observer, or to another by whom the specimens are to be examined and their significance interpreted.

SPUTUM. From many standpoints, the sputum, in disease, possesses very great importance. Its bulk is made up of pathological secretions, abnormal cellular elements, occasionally tissues and rarely stones, all of which are of great diagnostic significance; at the same time, it is the vehicle in which the pathogenic agents of many diseases, both local and general, make their exit from the body. From a mere visual examination, the trained observer can detect the presence of features characteristic of certain diseases, and abnormal ingredients that are suggestive of disorders of certain organs; while with the microscope

he can observe the presence of bacteria, animal para-
sites or their eggs, and the various other constituents
invisible to the unaided eye.

Attention should always be given to the
Amount. amount of sputum expectorated in the
twenty-four hours, since only in this way
can an increase or decrease be definitely determined.
A daily record should be kept of the quantity, other-
wise in the rush of other work valuable information
may be lost. Especially important is a knowledge of the
amount of expectoration in case of hæmorrhage, or of a
sudden large increase, as may occur when an hepatic
abscess ruptures into the lungs. The twenty-four
hours' quantity should be measured for the reason that
many patients (e.g., pulmonary tuberculosis, bron-
chiestasis) expectorate chiefly only during one or two
hours in the twenty-four, so that if the amount expelled
at this time is not taken into account, a report of a scanty
expectoration might be made.

Consistence of a sputum is another charac-
Consistence. teristic of importance; it may be thin and
watery (serous), or so heavy and tenacious
that the vessel may be inverted without spilling its con-
tents (mucoid). Mucoid sputum is seen most charac-
teristically during the stationary period of pneumonia.
Between these two extremes there may be various de-
grees of consistency, or the sputum may consist of both
elements distinctly discernible (muco-serous). Thus,

in pulmonary tuberculosis, when the sputum-cup has stood awhile, the contents are seen to consist of an upper watery layer, and a lower tenacious mass which, when shaken, is seen to be made up of round, coin-like particles. This is the so-called *mummular* sputum which is characteristic of the second and third stages of consumption.

Worth remembering also is the fact that on standing twenty-four hours or longer in a warm room, a tenacious sputum may become liquefied through solution of its mucus by ferments.

COLOR.   Much valuable information may be derived from the color of a sputum. Sputum may vary from the clear glairy appearance of normal saliva, to grey, yellow, green, red, brown, and even black. A greenish or yellow color indicates either pus (purulent), or bile (bilious); a red color, blood (sanguineous); a brown or chocolate color, liver abscess; and black, carbon, a condition resulting from the inhalation of carbon particles as is practised by smokers for pleasure or by miners from necessity.

ODOR.   If there is anything unusual to the odor of a sputum, it should be noted. Most sputa are practically odorless. However, under certain circumstances, e.g., putrid bronchitis, the other extreme is presented, and the offensiveness of the expectoration beggars description. In pulmonary tuberculosis the sputum has a sweetish odor.

DESCRIPTION OF A SPUTUM. In describing a sputum a single predominating characteristic is selected. Thus as types we have the mucoid, the purulent, the serous, and the sanguineous. Where two or more elements are plainly mingled, such terms as muco-purulent, muco-serous, sero-sanguineous, and sanguino-mucopurulent, are used to describe it.

Sputum is most frequently examined for the tubercle bacillus, and where it is to be submitted to an expert with this object in view, the following directions should be observed: "Collect the sputum in a clean one or two-ounce bottle with a wide mouth and a water-tight stopper. The bottle should be labeled with the name of the patient. The sputum coughed up in the early morning is to be preferred. If the expectoration be scanty, the entire amount coughed up in the twenty-four hours should be collected. Care should be taken that the contents of the stomach, food, etc., are not ejected during the act of coughing, and collected instead of pulmonary sputum. Purulent, cheesy, and muco-purulent sputa most frequently contain tubercle bacilli; pure mucus, blood, or saliva do not as a rule contain them. When hæmorrhage has occurred, if possible some purulent, cheesy, or muco-purulent sputum should be collected for examination. The sputum should be forwarded in as fresh a condition as possible."

In suspected diphtheria, for the purpose
DIPHTHERITIC of diagnosis, and after recovery from diph-
CULTURES.   theria, before raising the quarantine, to
determine the presence or absence of the
specific bacillus, it is compulsory in many cities that a
specimen be taken from the patient's throat and sent to
the municipal laboratory for examination. For this pur-
pose a special outfit is furnished consisting of two glass
tubes, one, containing a sterile swab, the other, a cream
or chocolate colored jelly which fills about one-third of
the tube. The material in the second tube is blood-
serum which has been solidified in a slanting position
by heat. To make a culture, the swab is first smeared
over the affected area in the throat, and then immediately
applied to the slanting surface of the blood-serum. The
tubes are then returned to the laboratory where the one
containing the blood-serum is placed in a warm oven
($37.5°$ C.—$98.6°$ F.) for from twelve to eighteen hours.
A stained preparation of the bacteria, which by this
time have developed upon the blood-serum, is now ex-
amined with a microscope, and the presence or absence
of diphtheria bacilli determined. The following di-
rections, taken from the literature of the Philadelphia
Health Department, is an illustration of the instruc-
tions which accompany the tubes:

DIRECTIONS FOR MAKING CULTURES.

"The patient should be placed in a good light, and,
if a child, properly held. In cases where it is possible

to get a good view of the throat, depress the tongue and rub the cotton swab gently, but freely, against any visible exudate, revolving the wire between the fingers, so as to bring all portions of the swab in contact with the mucous membrane or exudate. In other cases, including those in which the exudate is confined to the larynx, pass the swab as far back as possible, avoiding the tongue, and rub it freely as described above against the mucous membrane of the pharynx and tonsils. With-
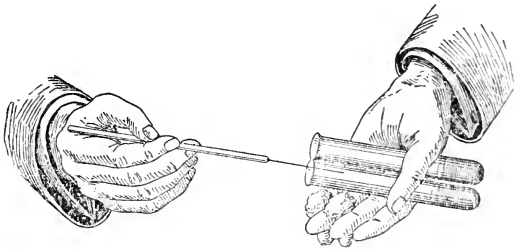
FIG. 27.—Method of inoculating culture media. (Williams.)

draw the cotton plug from the culture tube, holding it so that the portion withdrawn from the tube does not come in contact with the fingers or with any other substance. Insert the swab and rub it gently but thoroughly back and forth over the entire surface of the blood-serum. Do not allow the swab to touch anything except the throat of the patient and the surface of the serum. Do not push the swab into the serum, nor break the surface in any way. *Do not use*

tubes in which the serum is contaminated, is liquefied or is dried up. Then replace the swab in its own tube, plug both tubes, mark the culture tube with the name of the patient for identification, and return both tubes to the laboratory. Unsatisfactory cultures usually result from failure to follow carefully the above directions." Caution: In making cultures, to insure a successful result, no antiseptic must have been used in the patient's throat for an hour preceding the taking of the culture.

In croup, a membrane is often coughed up, which it is sometimes desirable to have examined to determine the nature of the infection, i.e., whether diphtheria is present or not; in such cases it is especially important that the specimen be not placed in any preserving fluid or disinfectant, since such solutions destroy the very agents which it is aimed to find.
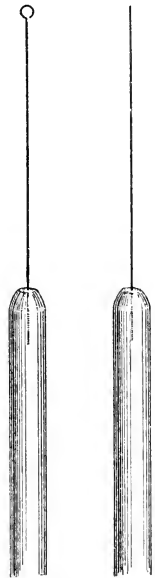
Fig. 28.—Needles used for inoculating media.

Vomiting is a feature in VOMIT. local diseases of the stomach; in affections of neighboring organs (heart, liver); it also occurs at the onset and during the progress of the infectious diseases. The points to be observed in vomiting are the time, color, odor, quantity, and ingredients.

Time. The time of vomiting is important, especially in relation to meals. It should be noticed whether vomiting immediately follows the ingestion of food, or is delayed some minutes or hours; also whether it apparently results from the ingestion of some particular article of diet. Vomiting may be frequent, as in the early months of pregnancy, or it may be sporadic, as in dilatation of the stomach. Sudden, unexpected, vomiting practically always marks the onset of the eruptive fevers in children.

Color. Color is given to the vomit either by the foods ingested, or by foreign or pathological constituents such as bile, blood, mucus, etc.

Bile. As a rule the vomit is green or golden in color from admixture with bile, a secretion which is always present in intense or continuous vomiting.

Blood. Red vomit usually results from admixture with blood. If the blood has not been acted upon by the digestive juices, it is easily recognized; but the gastric ferments may so alter its appearance that the vomit may vary from a deep-red to a coffee or black color. Black vomit, it will be remembered, is a characteristic symptom in yellow fever. Vomit may also be dark from the presence of stercoraceous material (feces). Care should always be taken not to mistake food for evidence of pathological

vomit. The writer was once sent the red vomit of a pregnant woman for examination, hæmorrhage being suspected. The red color was due to nothing more serious than ripe tomatoes which anyone might have seen had they looked well.

Odor. The normal odor of the gastric contents is acid. In disease, it may be "beefy" from the presence of blood; putrid in cancer or dilation; ammoniacal in uræmia. In stercoraceous vomiting it has the characteristic odor of the stools.

Quantity. Measure or gauge as accurately as possible the quantity vomited. The normal stomach has a capacity of three pints, an amount which may be increased in dilatation to three or more quarts. The quantity vomited also furnishes important information as to the absorptive and digestive powers of the stomach, especially when considered in connection with the amount and kind of food ingested. To obtain the latter data, physicians are in the habit of giving a measured quantity of food (test-meal), and within an hour withdrawing it with a stomach-tube for examination.

Test-meals. Test-meals are given either in the morning or at noon, and, depending upon the time given, are called respectively test-breakfast or test-dinner. The most common test-meal is the breakfast. Two breakfast formulæ are in common use,

which are named after their originators, Ewald and Boas.

TEST-BREAK-FAST OF EWALD AND BOAS. Consists of from 35 to 70 grams (2 ounces) of wheat bread, and of 300 to 400 cu. cm. (1½ to 2 glasses) of water, or weak tea without sugar.

TEST-BREAK-FAST OF BOAS. Consists of oatmeal soup, prepared by boiling down to 500 cu. cm. (17 fluid ounces) one liter (quart) of water to which one tablespoonful of rolled oats has been added. A little salt may be added, but nothing more.

TEST-DINNER OF RIEGEL. Soup 400 cu. cm. (2 glasses), beefsteak 200 grams (7 ounces), wheat bread 50 grams (1¾ ounces), water 200 cu. cm. (1 glass). Finely chopped meat may be substituted for the beefsteak.

INGREDIENTS. Besides the contents already mentioned above, the vomit always contains more or less mucus and saliva. Food in all stages of digestion will be noticed, and, if present, the segments (proglottides) of tape-worms, the adult round worm (ascaris lumbricoides), and the thread-like trichinæ. Foreign indigestible objects, which have been swallowed, may be discovered, such as pins, needles, whistles, etc. These are found most often in the vomit of children, the insane, and in hysterical subjects. In the last class of patients the most rigid surveillance must be practised to prevent deception.

From an examination of the blood alone,
BLOOD the diagnosis of a limited number of dis-
SPECIMENS. eases can often be made. In a few, as
for example malaria, the agents of the dis-
ease can be detected with the microscope in properly
prepared specimens; in others, e.g., typhoid fever,
when a drop of blood is brought in contact with known
typhoid bacilli, a characteristic phenomenon, *Widal's
reaction*, takes place, which consists in a clumping or
drawing together of the bacilli; in still another class of
diseases, the diagnosis is made by determining the
number of red and white corpuscles present in one
cubic centimeter of blood, and noting in what respects
their number and appearance differ from that which is
normal. In cities maintaining municipal labora-
tories, outfits for the collection of specimens of blood
for the diagnosis of both malaria and typhoid fever are
supplied.

This outfit for typhoid fever consists of
TYPHOID either a slip of unglazed paper, a glass
FEVER slide, or a metal plate, upon which the
(Widal) blood is to be collected, and a needle for
OUTFIT. puncturing the ear or finger. These with
the directions for taking the blood are
enclosed in an envelope.

The directions for taking the blood-drop on paper
are as follows:

"Thoroughly cleanse the skin of the patient's finger-

tip or the lobe of the ear. After carefully drying, prick it with a needle previously sterilized by heating over a lamp or gas flame and allowed to cool. Allow five or more large drops of blood to dry on the inner surface of a piece of paper. Replace the folded paper in the envelope, and return to the laboratory." Where a glass slide or a thin sheet of metal is used in place of the
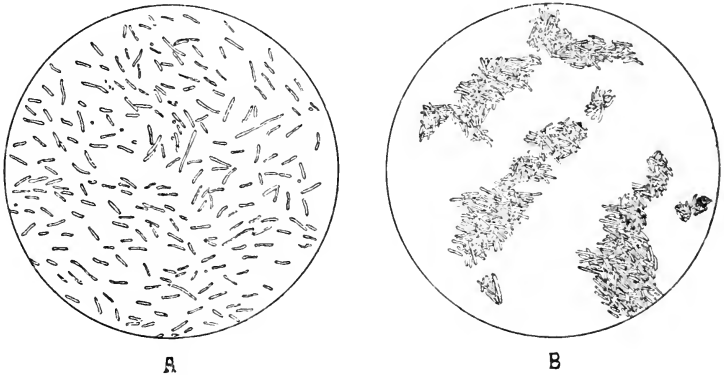
FIG. 29.—Application of the Serum-reaction to Typhoid Bacilli. (Williams.) A, shows the distribution of the bacilli before the reaction. B, shows clumping of the motionless bacilli after mixture with the serum of a case of typhoid fever. (Diagrammatic.)

paper, the directions for the collection of the blood specimens do not differ materially from the above.

As a rule the Widal reaction is not given by the blood in typhoid fever before the sixth or seventh day, and sometimes not until almost the end of the sickness; for this reason it is advisable to prepare a second specimen of the blood after a few days in case the first specimen

proves negative.   In about five per cent of the cases the reaction is never obtained during the whole course of the disease, a fact, it would appear from recent studies, due to the presence, as causative factor in the disease, of another bacterium, the para-colon bacillus.   Blood from such a case when tested with a para-colon bacillus, gives the characteristic reaction.

MALARIA.   For the detection of the malarial parasites either glass slides or cover-glasses are used, the former being given the preference by the majority of municipal laboratories.   The directions for preparing specimens of blood in suspected malarial fever as given by the New York Health Department, are as follows:

"Wash two glass slides with alcohol, and wipe with a soft, clean linen cloth (not a soiled handkerchief) until clean and shiny.   On cold, damp days the slide should be warmed over a flame.   After cleaning, the slides must be held by the sides (F F in diagram), and surfaces and ends not touched.   Clean the patient's ear-lobe with alcohol and prick the skin with a sterile, surgical needle or a small pointed scalpel, so as to actually incise the capillaries.   The blood should not be squeezed out, but should flow freely.   Wiping off the first few drops, the third or fourth drop should be quickly (before it gets much larger than a pin head) taken up on the edge of one end of one slide.   Place this edge on the surface of the other slide, as indicated

in the diagram, and as soon as the blood-drop has spread along the line of contact, draw the upper slide gently along the surface of the lower, thus spreading the blood in a thin film. Dry this by waving in the air. *Do not heat.* Repeat the process, using the edge of the prepared slide to spread the blood upon the other slide. The blood should be taken before quinine has been administered, as quinine quickly expels most of the malarial parasites of this latitude from the capillary blood. Under such circumstances negative reports
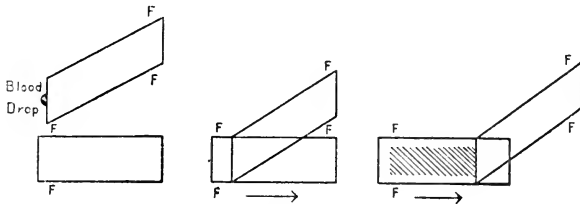
FIG. 30.

count for little or nothing. The blood should be drawn *just before, during, or just after the supposed* malarial paroxysm, as the parasite is present in the capillaries in much greater numbers at those times."

When cover-glasses are preferred, two or more cover-glasses are cleansed in precisely the same way as described for slides. A small drop of blood is caught in the center of one cover-glass by bringing the latter in contact with the former. Then the second cover-glass is allowed to fall gently upon the other. If the glasses have been well cleansed, the blood will immediately

spread in a thin layer between them, when they are at once separated by gently drawing one over the other in the same plane, i.e., parallel to the other.

SPECIMEN FOR CORPUSCULAR EXAMINATION.
If an examination of the red and white elements of the blood is to be made, blood films are prepared upon slides or cover-glasses in the same way as described for malaria.
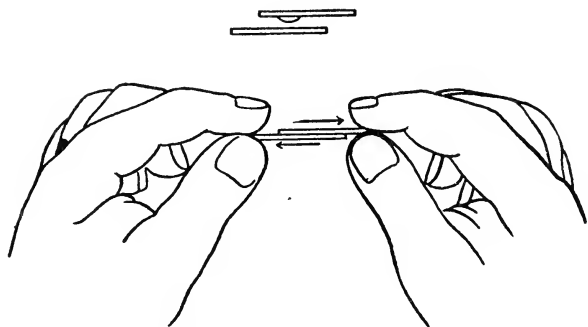
FIG. 31.—Cover-glass is touched to summit of a drop of blood and then allowed to fall on a second cover-glass, margins overlapping. Method of separating cover-glasses. (Clinical Diagnosis, Boston.)

PUS AND OTHER DISCHARGES.
The microscopical examination of purulent or other discharges often permits of the immediate discovery of the agents causing a disease, a fact which may be of incalcul-able benefit to the patient, and a sure guide for the doctor. This is the case, for example, in puru-lent ophthalmia, a suppurative conjunctivitis most fre-quently observed in the new-born, although also found

in adults, and which if not recognized speedily leads to permanent blindness. Specimens of such discharges are collected upon slides or cover-glasses in the same way as described for malaria, care being exercised that the smears are not too thick. In making smears in this class of cases, it is safest, on account of the danger of self-infection, to use an object easily destroyed, as for example a tooth-pick, which is then burned.
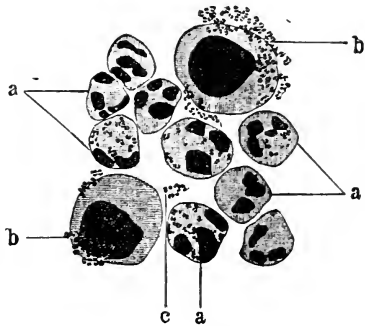
FIG. 32.—Intra-cellular (a) and (b., c.) extra-cellular gonococci. (Casper.)

URINE.   No secretion during sickness is subject to closer scrutiny than the urine. It is the chief avenue for the elimination of nitrogen from the body, as well as for other substances which, if retained, are distinctly harmful. In many diseases it is the channel of exit for the specific bacteria from the body. Such highly significant data bearing upon a patient's illness are obtained from a study of the urine, that the precise condition of this secretion is always ascertained.

COLOR.   Normal urine, when freshly voided, should be perfectly clear or faintly cloudy. Its color is variable, verging from a light yellow

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or straw, to a brownish-red. The color of all urines deepens upon standing, while at the same time a cloud forms which gradually sinks to the bottom of the vessel which contains it. Urines which are allowed to get chilled are often quite cloudy or opaque, and when presenting this appearance are sometimes taken to indicate an abnormality in the secretion. Opacity from this cause is quickly dissipated on the application of heat.

Pathological urines exhibit the same variations in shades as the normal. The color of all urines is subject to seasonal variation, being pale in winter and dark in summer. A pale urine simply indicates an excess of water. The color of urine is also influenced by the food ingested.

Urines are described as:

(1) Pale or straw color.

(2) Amber.

(3) Reddish-yellow or red (high color).

(4) Reddish-brown (dark urine).

Besides these shades the urine may be green from bile, red from blood, black from melanin, blue from indican or after the ingestion of methylene blue, yellow from santonin or rheum, and milk-like from the presence of pus or chyle (chyluria). In filariasis, the urine may contain both chyle and blood, a condition to which the name *hæmatochyluria* has been given.

BILE.   Bile imparts to urine a yellow or greenish-brown color, and can usually be detected at once upon inspection. If a urine containing bile be shaken, the foam which collects upon the top will be found of a yellowish or greenish hue even when these colors are not pronounced in the body of the urine. The same urine when filtered also leaves a greenish stain upon the filter-paper.

SMITH'S TEST FOR BILE.   Five to ten cubic centimeters of urine are placed in a test-tube and treated with two to three cubic centimeters of tincture of iodine (which has been diluted with alcohol in the proportion of one to ten) in such manner that the iodine solution forms a layer above the urine. In the presence of bile, a distinct emerald-green ring is seen at the zone of contact.

BLOOD.   Blood gives urine a color which may vary from bright red to dark brown. Such urine turns darker upon standing. In cases in which blood is voided, it is important that the urine of a single micturition be passed in two or three portions. A person voiding urine mixed with blood is said to suffer from *hæmaturia*. When the blood is dissolved in the urine, i.e., the hæmoglobin has left the corpuscles, the condition is called, *hæmoglobinuria*. Sometimes it is difficult to distinguish blood from bile in urine, as both may present the same appearance. They can usually be distinguished by dilution with water

which acts so as to bring the red color of the blood more prominently into view.

Pus. Urine containing pus, when allowed to stand a short time, exhibits a heavy white or creamy precipitate. If shaken or poured out, it is seen to be tenacious or stringy. Pus is often associated with blood in the urine.

GREEN URINE. Salol is so frequently prescribed, that attention is directed to the fact that urine voided by a patient taking it becomes green and eventually black upon standing.

QUANTITY. The quantity voided in the twenty-four hours is subject to great variations, usually bearing a relation to the quantity of fluids ingested. Exercise, sleep, temperature, atmospheric moisture, all influence the urinary secretion.

An adult ordinarily voids between twelve hundred and fifteen hundred cubic centimeters (thirty-five to fifty ounces) of urine in the twenty-four hours. Most individuals do not void urine after retiring; and if this has been the rule, a departure from this habit should be viewed with suspicion.

POLYURIA. *Polyuria* is the condition in which unusually large amounts of urine are passed in the twenty-four hours. An extreme grade of polyuria is common in diabetes; and in that form in which sugar is also present (diabetes mellitus), twenty-five or more liters (quarts) is not very unusual.

OLIGURIA.
Oliguria is that condition in which amounts of urine below the average are passed.

Usually it is a very serious symptom; however, it is occasionally seen in neurasthenics.

ODOR.
The odor of urine is of slight significance. The normal odor is described as like that of "bouillon," "oysters," or "new hay." Uriniferous, as applied to urine, describes its odor after decomposition has taken place. Freshly voided urines which are uriniferous are pathological.

SPECIFIC GRAVITY.
The specific gravity of the urine is determined with an instrument called a urinometer. With the urinometer is supplied a cylindrical vessel which is to hold the urine while the specific gravity is being taken. To determine the specific gravity the cylinder is nearly filled with urine, when the urinometer is slowly introduced. The specific gravity is read directly from the scale at the upper end of the instrument where the surface of the urine meets a division on the scale. A sample of the twenty-four hours' output should be employed.

FIG. 33.—Simple Urinometer and Accessories. (Greene.)

Normally the specific gravity varies between 1010 and 1025; pathologically, between 1002 and 1060. Urines containing albumin have their specific gravities

between 1005 and 1010; those containing sugar, between 1030 and 1040. To be sure, these limits are often exceeded or diminished.

REACTION. The reaction of normal urine is acid, although specimens passed at different times may be neutral. The reaction of a urine is obtained by wetting pieces of filter-paper which have been colored red or blue by saturation with red or blue litmus. If a urine be acid it will impart to the blue paper a red color; if alkaline, the red paper will be changed to blue. Normal urines sometimes alter the color of both papers slightly; such urines are said to be *amphoteric*. The latter is of no significance.

ALBUMIN. Albumin in urine is always an indication of disease. Tests for its presence should be made as a routine procedure.

NITRIC ACID TEST. To determine the presence of albumin, (1) fill a test-tube two-thirds full of urine and apply gentle heat to the upper surface until it begins to boil. Now add a few drops of concentrated nitric or acetic acid. Should the urine remain clear it is free from albumin; if cloudy upon boiling, and the cloud does not clear up upon the addition of the acid, it contains albumin.

CONTACT TEST. (2) Add a few cubic centimeters of concentrated nitric acid to a test-tube and, while inclining the tube at an angle of about forty-five degrees, with a pipette let

a few cubic centimeters of urine flow down the sides of the tube so that it floats upon the acid. Hold the tube straight and to the light, when if albumin be present a white ring will be seen at the junction of the two fluids.

Caution: Filter the urine before applying any test for albumin.

SUGAR TEST. The presence of sugar in urine is determined by heating a few cubic centimeters of Hain's solution in a test-tube, and then immediately, upon removal from the flame, adding a few drops of the suspected urine. If sugar is present the blue color of the solution will be changed to a canary or reddish yellow. Always boil and filter urines containing albumin before applying the test for sugar.

FOREIGN SUBSTANCES. Bacteria, and the eggs of animal parasites, are also at various times eliminated in the urine. But as this phase of the subject is treated in detail in another chapter, reference is made to it here for the sake of completeness only.

At times, however, other things are voided in the urine which should be spoken of in this place. Reference is made to gravel and stones from the kidneys or bladder, hair from dermoid cysts, fecal matter (in vesico-rectal fistula), etc. In hysterical subjects and the insane, hairs, beans, fish-bones, etc., may be actually

voided, or be passed off on the physician as having been voided. Where the objects are really passed in the urine, they are introduced into the urethra or bladder before micturition. Hair, however, may be passed in the urine in cases of dermoid cysts of the bladder.

COLLECTION OF SPECIMEN. When preparing a specimen for examination, a portion of the full twenty-four hours' secretion should be chosen. Although this does not always furnish the most satisfactory sample, it is the safest rule to follow in the absence of specific instructions. In one form of Bright's disease, for example, albumin is present only an hour or two after meals, and then in very small amounts, so that the examination of a twenty-four hours' mixture might not reveal its presence. In like manner, in diseases of the genito-urinary organs, the twenty-four hours' secretion does not give as much information as one or several specimens collected during a single act of micturition; and in affections of these parts the patient is directed to divide his urine while voiding it into two or three portions. If possible always send at least four ounces of urine for examination. Unless the urine can be examined in a few hours, keep it in a cool place; or add to it gr. v of boracic acid, or one dram of chloroform, to every four ounces of urine. Formalin, m. i to four ounces, is also an excellent preservative.

FECES.

The observations to be made of the stools include the number, amount, consistence, form, color, and odor of the movements, and further, the presence or absence of mucus, blood, pus, gas bubbles (which denote fermentation), animal parasites (e.g., worms or segments of same), foreign bodies (e.g., pins, coins, etc.), gall-stones, and undigested food particles. When blood, pus or mucus is discovered, its relation to the rest of the movement should be noted, that is to say, whether the same is mixed with the stool, clings to it, or is passed separately before or after.

NUMBER.

Normally the number of stools in different individuals is subject to great variations, so that it is impossible to fix a standard which will apply to every one. Thus, while it is usual for the majority of persons to have at least one movement in the twenty-four hours, it is not uncommon to find some who exceed this number by one or two stools, and still others for whom one stool in two or three days is apparently normal. Wide variations in the number of stools is compatible with good health. For the average person, however, at least one movement daily is requisite; less than this number constitutes constipation, and more, several loose movements, diarrhœa. Both constipation and diarrhœa are important symptoms not only in diseases of the alimentary tract, but of systemic affections as well, and the history of no case is complete without a record of the state of the bowels.

AMOUNT.   The amount of fecal matter does not vary so much as the number of stools, since the greater the number, the smaller the individual movements, and vice versa. The size of the stool bears a relation to the kinds of food eaten, a diet rich in vegetables and starchy foods leaving a much larger residue than one rich in animal proteids.

CONSISTENCE.   The consistence of a stool depends upon the amount of water present. In health the food determines the amount of the latter, being greater with a vegetable than a proteid diet.

Stools are described in regard to their consistency as thin, mushy, or watery; and hard and dry (scybalous).

COLOR.   The color of a stool varies with the character of the food ingested. It may be quite light, as in a person restricted to a milk diet; green from green vegetables; and black from a diet containing an abundance of rare or raw meat. All stools turn darker upon exposure to light. In disease the stools may be golden, yellowish-green, or green, from bile; pasty and greyish or white, in diseases of the liver or bile passages; red, brownish-red, coffee-colored, or black (tarry) from blood; dark blue from the administration of methylene blue. Calomel turns the stool green. The number of stools also has a bearing upon their color, the larger the number, the lighter the color of the individual movements.

EXAMINA-
TIONS.
Examinations of the stools are frequently advisable for the purpose of discovering, if possible, gall-stones, animal parasites, and eggs of parasites.

GALL-
STONES, ETC.
If gall-stones, worms, or any other abnormal constituent is to be sought in the stools, the following procedure is advisable:

(1) Have stools for twenty-four or forty-eight hours passed into a large vessel.

(2) Mix each stool with about a gallon of water and stir thoroughly; let stand for one-half hour and then carefully pour off most of the fluid.

(3) Add more water and mix as before.

(4) Cover another vessel with surgeon's lint, fastening same with cord or adhesive plaster, and pour the mixture upon the gauze.

In the detritus left upon the gauze, search for gall-stones, parasites, or any other foreign object. In place of the lint, a fine sieve may be used with which to strain the mixture. Gall-stones vary in size from a grain of sand to an olive and larger, and are usually of a brownish-green color. They may crumple to the touch, or be quite hard. Often they show the typical smooth facets on one or more sides. The appearance of parasites and the kinds usually encountered, are described in the chapter devoted to parasites.

For microscopical examination the feces should be passed into a warmed vessel and sent to a laboratory

at once; or in case this is not feasible, a small portion should be poured into a wide-mouthed bottle, and while en route to the examiner kept warm.

Parasites may be preserved for longer periods in either weakened alcohol or whisky. Gall-stones should be placed in a tightly stoppered bottle to prevent deterioration.

APPENDIX

WEIGHTS AND MEASURES.

1. ENGLISH.

   1 grain (gr.)
   1 ounce (oz.)..................=437.5 grains.
   1 pound (lb.)..................=16 ounces=7000 grains.
   1 minim......................=.91146 grain.
   1 fluidram...................=60 minims.
   1 fluidounce.................=8 fluidrams.
   1 pint.......................=20 fluidounces.
   1 gallon.....................=8 pints.

2. RELATIONS OF ENGLISH AND METRIC SYSTEMS.

   1 grain ....=64.8 milligrams.
   1 ounce......................=28.3 grams.
   1 pound ....=453.6 grams.
   1 gram.......................=15.432 grains.
   1 kilo.......................=2 pounds 3 ounces.
   1 minim ....=0.059 cubic centimeter.
   1 fluidram ....=3.5 cubic centimeters.
   1 fluidounce ....=28.39 cubic centimeters.
   1 pint.......................=567.9 cubic centimeters.
   1 cu. cm.....................=16.9 minims.
   1 liter......................=35.2 fluidounces.
   1 inch.......................=2.54 centimeters.
   1 foot... ....=30.48 centimeters.
   1 yard.......................=91.44 centimeters.
   1 centimeter.................=0.39 inch.
   1 meter ....=39.37 inches.

THERMOMETRIC EQUIVALENTS.

CENTIGRADE	FAHRENHEIT	CENTIGRADE	FAHRENHEIT
110	230	38	100.4
100	212	37.5	99.9
95	203	37	98.6
90	194	36.5	97.7
85	185	36	96.8
80	176	35.5	95.9
75	167	35	95
70	158	34	93.2
65	149	33	91.4
60	140	32	89.6
55	131	31	87.8
50	122	30	86
45	113	25	77
44	111.2	20	68
43	109.4	15	59
42	107.6	10	50
41	105.8	+ 5	41
40.5	104.9	0	32
40	104.0	− 5	23
39.5	103.1	−10	14
39	102.2	−15	+ 5
38.5	101.3	−20	− 4

Formulæ for converting degrees of Fahrenheit into Centigrade and vice versa.

F. = Fahrenheit; C. = Centigrade; D. = degrees.

Fahrenheit into Centigrade

$$(F. - 32°) \times \tfrac{5}{9} = C.$$

Example: 140° F. = 140−32 × $\tfrac{5}{9}$ = 60° C.

Centigrade into Fahrenheit

$$(C. \times \tfrac{9}{5}) + 32 = F.$$

Example: 10° C. = 10 × $\tfrac{9}{5}$ + 32 = 50° F.

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