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A MANUAL

OF

PRACTICAL HYGIENE

DESIGNED FOR

SANITARY AND HEALTH OFFICERS, PRACTITIONERS,
AND STUDENTS OF MEDICINE.

BY

W. M. L. COPLIN, M.D.,

ADJUNCT PROFESSOR OF HYGIENE, DEMONSTRATOR OF PATHOLOGY, AND CURATOR OF THE MUSEUM,
JEFFERSON MEDICAL COLLEGE; ADJUNCT PROFESSOR OF PATHOLOGY IN THE PHILADELPHIA
POLYCLINIC AND COLLEGE FOR GRADUATES IN MEDICINE; SURGEON TO ST.
MARY'S HOSPITAL; PATHOLOGIST TO THE PHILADELPHIA HOSPITAL;
LATE A. A. SURGEON, U. S. MARINE-HOSPITAL SERVICE;

AND

D. BEVAN, M.D.,

INSTRUCTOR IN HYGIENE AND CLINICAL MICROSCOPY, JEFFERSON MEDICAL COLLEGE; BACTERIOLOGIST TO ST. AGNES' HOSPITAL, PHILADELPHIA; ASSISTANT PATHOLOGIST, PHILADELPHIA HOSPITAL; ASSISTANT PATHOLOGIST, PHILADELPHIA POLYCLINIC AND COLLEGE FOR GRADUATES IN MEDICINE.

WITH AN INTRODUCTION BY

H. A. HARE, M.D.,

PROFESSOR OF THERAPEUTICS, MATERIA MEDICA, AND HYGIENE, IN JEFFERSON MEDICAL COLLEGE,
PHILADELPHIA.

WITH 140 ILLUSTRATIONS,
MANY OF WHICH ARE PRINTED IN COLORS.

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Dedication.

TO THE LABORERS AND STUDENTS IN THE FIELD
OF PREVENTIVE MEDICINE, BY

THE AUTHORS.

PREFACE.

The great importance given to the study of Preventive Medicine, or more correctly speaking, "The Causes of Disease," has in the last few years revolutionized nearly all the branches of medicine, and Sanitary Science is now made a compulsory study in nearly all medical schools. With these points in view the authors of this manual have endeavored to prepare a text-book, the first complete work from an American standpoint. The microbic causes of disease and the methods of detecting and combating them are all given full consideration. The various subjects, Water, Air, Food, Habitations, etc., have been thoroughly gone into, each one receiving the consideration its importance merits, one main idea being carried through the whole, *i. e.*, *the causes of disease, their methods of ingress, and the available means for their prevention.* Each subject is considered in its relation to disease production, and the method of prevention has been pointed out. It has been our desire to make the work a practical treatise, with a minimum of theory and a maximum of applicable fact. Where many methods of doing a thing are in vogue, the writers have assumed that the most satisfactory one, given in detail, would be more desirable than abridged descriptions of several.

Every attempt has been made to fully illustrate each section; illustrations have been inserted wherever they would more clearly elucidate the text. A large number of these illustrations are from special drawings made by Dr. Bevan, and while of artistic value, are scientifically accurate. These are to a large extent diagrammatic, our experience having indicated the superiority of this class of illustrations. The source of those pictures that are not original is acknowledged in the list of illustrations, with the exception of those loaned by reputable manufacturers to whom we have already acknowledged our indebtedness.

The many special subjects considered in this volume demanded much expert knowledge, and as it was the aim of the authors to make the book as accurate as possible, they have consulted with skilled specialists in various departments, and they wish to acknowledge here the kindness of National, State, and Municipal authorities who have granted valuable aid, and to thank Mr. Lockington for his help and advice in those sections where a knowledge of architecture was needed. We wish also to thank Mr. W. H. Smith, sanitary engineer, for valuable aid in supplying suitable illustrations for the article on Heating and Ventilation, and Drs. Leffmann and Beam, who have offered us the advantage of their wide experience in the study of Food Adulterations, Water Analysis, and collateral subjects. We are also indebted to Prof. J. W. Holland for valuable aid in certain chemical work.

In conclusion, we wish to thank the Publishers for many kindnesses and much labor in bringing the volume to its present condition of typographic and artistic perfection.

W. M. L. Coplin,
D. Bevan.

Philadelphia, *November 15, 1893.*

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INTRODUCTION.

When the undersigned was asked to prepare an introduction for this book, which at that time was only in outline, he was glad to consent, knowing that the practical experience and original work of the authors fitted them to prepare a manual pregnant with practical statements made in such a form as to be applicable in every-day life by the physician or sanitarian. The fact that numerous works on hygiene are already in existence proves that the importance of the subject is universally recognized, yet it is unfortunately true that in many instances these books are mere compilations of statistics or expositions of personal and, it may be, biased views. The want of a book on hygiene, written by a pen which at once recognized the needs of the physician, the student, and the public official, has never been more felt than now, and the authors of this book have not only recognized this fact, but occupy official positions which give them a personal insight into all the needs of those performing sanitary work. As an indication of the scope of this book, particular stress may be laid upon the chapters on the Causes of Diseases, chapters which are necessarily summaries of the advances made in bacteriology and kindred sciences within the last few years. Naturally, the methods of prevention of infection and the destruction of the products of disease processes are equally carefully considered, and in close relationship to this subject is the description of sophisticated and other forms of injurious food stuffs. The diseases of animals which are transmissible to man are also studied and original summaries of the latest discovered facts in this connection are presented, after thorough sifting of the uncertain statements from those which are reliable.

A grave deficiency in our medical learning has been the absence of reliable information about the various climates of the United States. Too often the climatologic reports are biased by the personal interest of the author in his own region, and the American physician is often at a loss where to send his patients on this side of the Atlantic. The recognition of the importance of this subject has resulted in a careful analysis of all scientific material concerning this matter, and has presented the profession with the information it needs, so far as it is possible to obtain it.

One of the slurs cast upon hygiene as a study of the day has been that very often the recommendations of the authors are only founded on theory, and not practically useful. It is difficult for the mind trained to scientific research to meet the objections of practical builders and architects, and the authors have therefore put their information in such a form as to be practically valuable by submitting all architectural points to an expert builder and architect. Closely allied to this branch of the subject is that of habitations in relation to site and building materials, and the chapter on heating is necessarily a careful product of scientific deduction and practical experience.

To the physician who delights in the addition of truly original matter to our store of information this book is a pleasant one to read, for other reasons than those already named, for it is illustrated by original illustrations in many instances, illustrations made by the pencil of Dr. Bevan from the results obtained by the perfect technique of the authors.

Heretofore the busy practitioner has often neglected hygiene, in its relation to private life, because the reliable books were, most of them, based on military needs. The architect has found that too often the stated scientific facts clashed with the utility of his building, and, as a result, in many instances serious hygienic sins were committed. It is to meet such cases that this book was planned and written, and that its objects have been accomplished will be evident to any one who is wise enough to study this important branch of knowledge in its pages.

H. A. HARE.

A MANUAL
OF
PRACTICAL HYGIENE.

CHAPTER I.

HYGIENE—HEALTH—CAUSE AND PREVENTION OF DISEASE.

There are two possible methods by which hygiene may be applied, or, it might be better to say, two views as to its application: 1st. *The maintenance of health.* 2d. *The prevention of disease.*

1st. **The Maintenance of Health.**

By health we mean that condition of the cellular elements, of organs and tissues, in which their functions are performed in a normal manner. That is to say, we have neither reduction nor increase, nor perversion of function beyond certain limits within which, for any given individual, we may consider normal. It may be largely the object of hygiene to retain cellular activity entirely within this limit, but more frequently the physician is called upon to prevent disease, and secondarily to maintain health. The first proposition is manifestly the more broad, as it of necessity embraces the second.

The laws to be laid down for the maintenance of health are obviously so broad as to cover encyclopedic dimensions, and besides, have such widely varying application, under different circumstances and for individuals in particular, that any attempt at formulation must prove futile. That which would retain the normal activity of Mr. B. would render the life of Mr. A. quite miserable. Thus we see that the rules of health are arbitrary and are determined, in any given case, by personal idiosyncracy. It is impossible, therefore, to promulgate any definite rules which may be universally applicable. While this is unquestionably true in a general way, when we come to the prevention of disease more definite knowledge will be demanded, and in order to comprehend and apply preventive measures the sanitarian should understand the causes of disease and the mutual relation subsisting between cause, effect, and result. A digression in that direction will, therefore, be pardonable.

Prof. Longstreth has very fitly put the relation of health to disease and its concomitant processes in a comparison to the picture of peace and war. In peace we have certain individuals either working alone or in aggregations, attaining definite results in one or more directions. They employ means often identical, varying only in their application, but in this way altering in important features the result attained. Then comes the cause for war. It may be apparent in some international controversy over matters of importance and far-reaching consequence, or it may be sufficiently indefinite to be styled petty, but, be that as it may, it is sufficient. This represents in our comparison the cause of disease. Then follows the perversion of individuals from their normal occupation into a new pursuit, that of a soldier, and with this comes the war. The same individual, a unit in peace, becomes a unit in war, and the materials utilized in peace are now converted into commodities of war. Then follow the battles, the long marches, the destruction of much found useful during peace, all this leaving behind a ruin more or less complete, which may or may not be converted again to usefulness in the peace which is to follow. Thus the picture is complete, disease being the war, the altered tissues and perverted structures left behind the results, both immediate and remote, differing only in the ability of reconstruction, in both cases there being much which the wisest and ablest efforts can never replace.

The pathologist has to consider and deal with the elements engaged in war; the sanitarian occupies the position of mediator; his effort is to reconcile, to prevent, to ward off, to compromise with, and to combat what we may term the international difficulties between cell and cell, between individual and environment, climate, occupation, and all the concomitants, which we shall be pleased to designate as the causes of disease.

It is not, in our opinion, possible that we should be able to comprehend and accomplish hygienic victories without thoroughly understanding at least the fundamental principles which underlie the etiology of disease; in other words, it would be useless, if not impossible, to prevent the condition without knowing the cause. For this reason, we will now proceed to consider more or less briefly the prominent factors which induce, either directly or indirectly, disease. Great care must be used, and it is not at all times possible to prevent confusion of cause with result. Thus, we are extremely likely to associate the pitting which follows smallpox with the disease itself. Still, there is no reason whatever why the pitted skin should not be in every respect normal except in appearance. The tendency of the human mind to regard as normal those things which look normal must be entirely disregarded in the consideration of hygiene, for while we are to utilize the senses to a large degree, it is to be remembered that functions, which constitute the processes of life, are to be our guides in the maintenance of health.

THE CAUSES OF DISEASE.

Disease may be said to occur as the result of (*a*) *inheritance*, (*b*) a definite exciting element, usually considered the *exciting cause*, more or less modified in effect by certain ill-defined conditions known as (*c*) *predisposing causes.* (*a*) *Inheritance*, as usually considered—and quite properly,—embraces two distinct conditions:—

(1) **Direct Inheritance** is the introduction of *materies morbi* co-instantaneous with impregnation of the ovum. As the best example which we possess of this condition, syphilis stands pre-eminent, although not alone. If either parent have constitutional syphilis, it is possible for the offspring to be infected with the disease *ab initio*, thus constituting positive inheritance.

(2) **Transmission of Tissue**, or functional peculiarity, is another manifestation of inheritance. We have transmitted normal conditions, such as physiognomy, color of hair, eyes, etc.; also abnormal structures, such as webbed or supernumerary fingers and toes, all going to prove the direct transmission of tissue peculiarity from parent to offspring. Equally tenable is the view that tissue may be transmitted unusually susceptible, or the reverse, to the inception of given diseases; the former condition is known as *inherited susceptibility*, the

latter as *inherited immunity.* As the best example which we possess of inherited susceptibility, or transmitted soil, tuberculosis stands most prominent; in tubercular families, generation after generation, although born apparently healthy, contracts the disease with an almost unvarying regularity. Another observation which strongly sustains this theory is, where in a family one parent has phthisis, the children inheriting the personal peculiarities of this parent seldom escape the scourge, while the children resembling the unaffected parent are more likely to escape. Examples of *inherited immunity* are less common. Families are, however, known in which certain contagious diseases of childhood, *e.g.*, scarlet fever, have never occurred, although abundant opportunity for contagion has been afforded. While considering immunity, we may refer to *acquired immunity,* a condition in which the resistance to a given disease is the product of changes manifested after the impregnation of the ovum. Thus, a child may possess immunity to smallpox by reason of its having acquired the disease in utero; or individual diseases induce immunity by a single attack, as is the case with the exanthemata. *Induced immunity* will be considered later.

Temperament.—Associated with this inheritance of soil and the transmission from parent to offspring of certain conditions, apparently pertaining to the tissues and predisposing to disease, usually of a definite character, as tuberculosis, there may be an inheritance of constitution which carries with it a tendency to the development of one or more diseases belonging to a class or group which are often widely different in many important factors. Thus, the "nervous" or "neurotic" temperament transmitted from one generation to another, and so on through a long list of diseases, not infrequently referred to as nervous or neurotic in origin. This form of transmitted predisposition differs but little from what is known as diathesis, examples of which we have in the gouty or rheumatic tendencies transmitted from generation to generation, and manifesting themselves upon the slightest provocation. The student of hygiene does well to bear in mind that with the inheritance comes, at least in many cases, transmission, in quite a different manner, of habit and environment, actively predisposing elements. Under this head there will be a general as well as a special predisposition. The habits of certain families in which gout is prominent, if applied to others in which the disease may be not only rare, but absent, would rapidly lead to the development of the malady. Thus, the physician will see that, in contesting the diathesis, consideration of environment and habit may afford him ample opportunity for a broad application of preventive medicine.

The prevention of inheritance, when malicious in its tendencies, lies, of course, in the proper mating of the human family, a remedy the application of which is attended with the greatest difficulties. It is, however, none the less our duty to direct the proper course in the face of an almost absolute knowledge of a refusal to heed the well-meant advice. In the absence of our ability to overcome the source we had best direct the stream, and by so doing offer a faint hope of securing immunity. The family with tubercular tendencies should choose their vocations and climate with the greatest care; the habits of the gouty should be directed in proper channels; and the food, exercise, and clothing of both be under constant supervision. Inherited diseases demand the same general procedures as acquired diseases.

Other important features in the predisposition to disease are: *Age*, *sex*, *race*, *customs* or *habits*, previous attacks of disease (to be sharply differentiated from the sequelæ), external conditions, heat and moisture, climate, etc., which for the most part are rarely sufficiently alterable to deserve our notice—in other words, they are out of the domain of applicable hygiene. There are, however, certain marked tendencies to disease which manifest themselves, for the most part, in the presence of two causes, either of which may be considered as a predisposing element. Thus it is well known that the extremes of life, the very old and the very young, are pre-eminently prone to inflammatory processes affecting the mucous membranes, and so it becomes a duty to remove, as far as possible, other elements usually associated with such lesions—for example, extremes of temperature, exposure, improper food, etc.

There are certain functional predispositions; especially is this true of surgical diseases; thus, the very prominence of the nasal bone and mammæ make them liable to injury and its results. In medicine, the continual filtering process of air, at varying temperatures and with disease-producing materials in suspension, going on in the lungs affords, without a doubt, ample explanation for the prevalence of pulmonary disorders.

Occupation is often actively predisposing. Not only is occupation a predisposing cause, but the environment with which it is associated renders the induction of a given disease almost an absolute certainty. The coal-miner, the scissors- and knife-grinder, stone-cutter, and marble-dresser, are all subject, to a greater or less degree, to the invasion of the artisan's phthisis. If there be that element of predisposition which we have classified as a tubercular proclivity, there is almost certain to be developed a tubercular process; on the other hand, the individual who possesses a normal or increased resistance to tubercular invasion suffers from that form of artisan's phthisis usually considered as fibroid or interstitial pneumonia. Another case in which the poison enters from without, and which will be classed further on as among the ingestive disorders, largely due to occupation, is lead poisoning, and this differs only in the metal from the other forms of metal toxemia so constantly observed. So that these may be considered as ingestive causes rather than those purely due to occupation, the occupation merely being the means or method by which the ingestive process takes place. Although anthrax is a specific disease of microbic origin, which we shall consider later on, certain forms of it come under the head of diseases in which the occupation is an actual predisposing cause. Thus it has been known as wool-sorter's disease, on account of the frequency with which the handlers of hides and wool are attacked by the disease.

Previous attacks of disease predispose, in the large majority of cases, to recurrence of the same disorder. While this is usually the case, it is not by any means always true; for example, we rarely escape with a single attack of acute articular rheumatism, and, on the other hand, one rarely suffers from two attacks of any of the exanthemata. Thus it is to be observed that previous attacks of disease may produce that form of immunity known as acquired, or may predispose the individual to a second attack. One disease may be predisposing to another; as an example of this we have diabetic gangrene and suppurative processes which not infrequently accompany diabetes. It is also equally true that a patient suffering from a catarrhal condition of the lungs may—indeed, is extremely likely to—become infected by the bacillus of tuberculosis. Thus the writers have observed a case of chronic catarrhal pneumonia, with absence of any bacilli or lung tissue in the sputum, develop both after six weeks' residence in a hospital in which, unfortunately, the bed occupied by the patient was immediately adjacent to a case of tuberculosis. So great is this predisposition of one disease to the development of another that the life insurance companies regard such risks as undesirable. The prevention of diseases due to occupation lies in the immediate removal of the cause, and wherever feasible the same applies for the prevention of any disease which follows consecutively upon another.

In diseases where ingress to the system occurs through food, that is to say, swallowed, we speak of the process as *ingestion*, and such diseases are known as *ingestive diseases*. Prominent among the ingestive causes of disease we have improper diet, intemperance, and the varying forms of what we are pleased to call poisoning. The character of these poisons varies to an enormous degree, and include not only the preformed poisons, such as arsenic, for example, but materials whose toxic activity may be dependent upon subsequent changes. Thus every one will be free to admit that starchy foods are not actively poisonous in their action; however, by long use they set up conditions in the alimentary canal which vary but little from acute conditions brought on by the ingestion of well-known poisonous bodies. All forms of intemperance are injurious, alcoholic being the more grave merely because it is poisonous from the beginning. There are abundant reasons for believing, from a physiological standpoint, that alcohol is a food; this does not, however, offer the least excuse for intemperance in that direction, as when used in excess it no longer can be utilized by the tissues as nutrition, but immediately asserts its toxic activity. As already referred to, metallic poisoning may be classed either as ingestive or as due to occupation. Among the conditions ingestive in origin we have helminthiasis and internal parasitic

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diseases in general. These, of course, cover only those diseases parasitic in origin where ingress is secured through the alimentary canal.

Among the *exciting causes* of disease we have most prominently brought forward mechanical causes, chemical causes, thermal causes, and the introduction of specific morbific agents from without. This has led some writers to consider causes as exopathic, that is, from without, and autopathic, that is, induced purely from within. This classification is, as must be all other classifications, unsatisfactory. It, however, presents no advantages and many disadvantages. The mechanical causes include, for the most part, surgical diseases only, as traumatism, etc. The prevention of these is not within the domain of hygiene.

The chemical causes of disease have been, within the past few years, entirely restricted to the action of chemical bodies upon the organism; that is, bodies externally applied or introduced purely from without. It has, however, been shown that under varying conditions there may be developed within the organism toxic agents in many instances more poisonous than forms usually introduced from without.

Under the division of thermal exciting causes, we have the extremes of heat and cold leading to actual necrotic processes, thus bringing them within the domain of the surgeon. Again, there are certain diseases in which heat and cold play more important parts. Thus, the diseases of the mucous membrane which are brought about directly through the influence of heat and cold modified in their application; if the cutaneous circulation be extremely active, and the temperature reasonably high, a sudden change to low temperature leads to rapid contraction of the superficial capillaries and a determination of the blood to the viscera; later, these organs suffering in a direct proportion to the intensity of the congestion. There can be no doubt but what this is, occasionally, the mechanism of the diarrhea, dysentery, and other catarrhal conditions so frequently observed in soldiers and in the inhabitants of tropical climates.

Temperature may play an important part in the causation of disease. Thus, heat stroke and heat exhaustion are due to the influence of elevated temperature. It would also seem that sudden change of temperature is equally important. Humidity alone or combined with temperature is often a predisposing factor. Modified air pressure, above or below that to which the individual may be accustomed, not only predisposes to disease, but gives rise to definite processes, one of which receives its name from the caisson, which has of late brought the manifestations prominently forward. Increased air pressure does not seem to be so prominently a cause of morbid changes as does diminished barometric weight. This is evinced more actively when the change is rapid, as is shown in caisson disease, in which no symptoms manifest themselves until the withdrawal of the compressed air, or the individual moves into a more rarefied atmosphere, when the disease suddenly develops. As the effects of altitude are largely due to the rarefied condition of the upper layers of the atmosphere, rapid changes give rise to alteration in function, just as does removal from the caisson. It has become apparent, therefore, why mountain excursions not infrequently are productive of marked disturbance in individuals suffering from pulmonary or cardiac disease.

Among the most prominent exciting causes of disease is to be considered *contagion*, by which we mean the transmission of disease from one individual to another, either direct, as by actual contact, or indirect, as through air, clothing, dejecta, etc. Contagion and infection are used for the most part synonymously, and the confusion which has arisen over their use is most profound. Although various attempts have been made since the discovery of the causes of many diseases to draw a sharp line between contagion and infection, none of the propositions are beyond criticism. The two classes of disease overlap each other, and the more fully we comprehend the cause of disease the greater becomes the difficulty when attempts are made to divide diseases into two groups, the contagious and the infectious. At the present time malaria seems to afford the best example that we possess of infection, and, if we may reason from our knowledge of that malady, we are led to consider it as a low order of contagion. That is to say, infection depends upon a specific agent, as does contagion; in the former, however, the vulnerability of the individual must be increased before the morbific agent can develop its specific activity. The matter is not one of sufficient importance to deserve all the cavil which it has brought about.

The causes of contagion, or, rather, the material which is transmitted from case to case, is a matter of great importance and has afforded abundant ground for disputes, many of which are now historical. There are reasons for believing that all contagious and infectious diseases depend upon some constant element in each individual disease. This agent never changes in the vast majority of cases, while in the small minority it would seem that the infectious material could produce more conditions than one, if we study it from a clinical standpoint alone. Thus the streptococcus pyogenes is presumed to cause erysipelas as well as suppuration, and possibly puerperal fever. These exceptions may, however, be more apparent than real, a little knowledge upon etiology and further investigation into the morphology of some of these organisms, with more thorough observations in pathology, may elucidate some of these apparent contradictions. Exceptions are rare, and we may safely decide that the essential element, both from the standpoint of cause and symptom, in contagious diseases is specificity. This continues for all time, and though there be variations in virulence the type does not change in any important factor. As to what the constant element is which is transferred from individual to individual, seems to become more apparent with the rapid strides in the study of minute plants or bacteria. This subject we will now proceed to briefly consider.

BACTERIOLOGY.

Bacteria, micro-organisms, microbes, or germs, names used interchangeably and, for the best part, synonymously, are minute vegetable plants. No satisfactory classification of micro-organisms has as yet been made. In order for any classification to have the stamp of scientific value, it should be based upon the character of growth and methods of propagation, and not entirely upon the shape and arrangement, as are the present methods. In the existing state of our knowledge, a scientific classification on the above basis is not as yet possible, as we have not sufficiently advanced in our study of these organisms to be able to give such a classification. With these facts borne distinctly in mind, we will briefly consider the following, which may be considered more as a method of nomenclature than a classification.

(A) **Blastomycetes.**—By Blastomycetes we mean budding fungi. Of these there are two great divisions worthy of consideration, the *Hypomycetes*, or mould fungi, and the *Saccharomycetes*, or yeasts. These are sufficiently common and scattered over and throughout the universe. So far as we know they are not, except in rare instances, disease-producing in man.

Hypomycetes. The most familiar example of the Hypomycetes is that greenish mould found on old boots, harness, and moist clothes which have been exposed to a sufficient degree of heat in a moist atmosphere. This is the pencil mould, or *penicillium glaucum;* so far as known it is not disease-producing in man, although in rabbits and other lower animals it is often actively pathogenic, even fatal. It grows upon the surface of the body where sufficient cleanliness is not resorted to, and in localities where dirt may be allowed to accumulate; thus it has been found in the ear by several observers. Another good example of the Hypomycetes is the *Aspergillus*, of which there are no less than eight forms. It is not disease producing in man, although in rabbits it is fatal. The *Erysiphe* belong to the Hypomycetes, and as an example of this group we have the *Oïdium tuckeri* and *Oïdium lactis.* Gravwitz has attempted to prove that the favus fungus (*Achorion schönleinii*), the fungus of tinea tonsurans (*Tricophyton tonsurans*), and the fungus of pityriasis versicolor (*Microsporon furfur*), are identical with the oïdium lactis, but the evidence in this direction is not, as yet, conclusive. These are all pathogenic.

Although of a doubtful origin it is probably best to here classify the fungus of actinomycosis, or "big jaw," as it is called in cattle. By different writers this fungus has been variously classified; some give it a distinct group by itself, others considering it as belonging to the Schizomycetes. Having no better place to classify this organism than among the Hypomycetes, we shall so place it until investigation affords a better understanding and enables us to give it a more definite location.

Saccharomycetes. These include the yeasts and torulæ, and the tribe to which belongs the "fungus of thrush," with which we are all more or less familiar. The yeast used in the culinary art to make bread rise, known as the saccharomycetes cerevisiæ, and the mother of vinegar, mycoderma aceti, or more properly the saccharomycetes mycoderma, belong to this class.

These organisms grow by budding, as is shown by the illustration. A single circular or oval cell extends outward into a shaft or prolongation which gives off a new bud, and this bud again gives off prolongations terminating in other buds, the process going on indefinitely. Though occasionally observed in the bodies of living human beings, so far as yet known the saccharomycetes do not produce any disease, with the possible exception of the thrush fungus already referred to.

FIG. 1.

SACCHAROMYCETES CEREVISIÆ. × 800 diam.
Showing the mother cells, the budding cells, and the spores within the cells.

Having thus considered the first great division of micro-organisms, we now proceed to consider the second, which is by far the more important, as it includes all those organisms commonly associated with, if not actually causing, disease.

(B) **Schizomycetes** or **Spaltpilze** or **Fission Fungi.**—These embrace the forms that are of greatest interest to us, as among them will be found the most important disease-producing germs. The subdivisions of this group are (1) Cocci, or sphero-bacteria, (2) Bacilli, or desmo-bacteria, (3) Bacteria, or micro-bacteria, (4) Spirilli, or spiro-bacteria. (After Cohn.)

(1) *Cocci*, or *sphero-bacteria*, are globular or spherical bodies resembling a billiard ball, and are, so far as we know at present, without spores. There are two subdivisions, or rather methods of naming, (*a*) by number, (*b*) by arrangement.

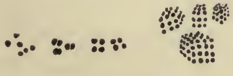
(*a*) *By number:* This method is resorted to when we have a coccus with a certain definite growth by number, *e. g.*, monococcus, or single coccus; diplococcus, or double coccus; tetracoccus, or four or quadruple coccus, *i. e.*, arranged in fours.

The monococcus includes those forms in which there is no tendency to regular grouping in any constant manner. The name is used synonymously with micrococcus. Some writers consider a group of organisms, cocci, as staphylococci, or growing as bunches of grapes. These have been usually placed among the next group, but the supposed method of growth upon which the name is based is far from apparent, and we do not believe it is a morphological characteristic of sufficient importance to be given a distinction, and shall, therefore, consider the group as identical with the micrococci.

A double or diplococcus usually consists of two hemispheroidal bodies with their flattened surfaces in apposition, a clear space showing between them, which is, as a rule, equal to about one-sixth the diameter of either coccus. More rarely, however, diplococci exist as two distinctly formed cocci arranged side by side, or, very rarely, they may be joined together like dumb-bells; the latter the writers have frequently observed in decomposing urine. It is likely that a monococcus during fission becomes a diplococcus; but that such is the case has not been proven.

The tetracoccus, or quadruple coccus, consists of cocci arranged in fours. The arrangement may be like that of an apple cut in quarters by an incision in the axis of the core and another at right angles, the different segments being slightly separated from each other. This is not the rule, however; in tetracocci they usually exist as four distinct spheroidal organisms. The best example of this organism is seen in the micrococcus tetragonus. Sarcina, or packet cocci, are by some classed under this head. They consist of packets of eight, resembling a bale of cotton. This characteristic might lead us to regard them as tetracocci in double or superimposed layers, a fact explaining fully their growth at times as bundles of sixteen or, more rarely, thirty-two or even sixty-four elements.

FIG. 2.



MONOCOCCI, DIPLOCOCCI, TETRACOCCI, AND SARCINA. × 800 diam.

FIG. 3.

STREPTOCOCCUS PYOGENES. × 800 diam.

Showing division in a single diameter, one continuous chain; also division in two diameters, producing a double chain.

By some observers the diplococci and tetracocci are considered under one head as merismopedia, while the sarcina are given a separate and distinct class; by others the latter are considered under the second division, that is, growth by arrangement.

The second method of naming cocci is by arrangement. Under this head we have several distinct forms which, for the most part, retain their identity under all conditions.

(*a*) *Streptococci.* These are arranged in chains like the beads of a necklace. They may be in a continuous line, monococci showing division in a single transverse diameter, or while dividing, as in this form, they may undergo a division in an opposite direction as well, thus giving the appearance of a chain of diplococci. Such division is shown in the accompanying illustration.

(*b*) *Ascococci.* Where cocci evince a tendency to grow in gelatinous masses or families having a definite form made up of solid growths with or without a capsule, they have been called ascococci, a name having a certain value under some conditions. They may be either planar or spheroidal, *i. e.*, the aggregation may be made up of cocci arranged in a single plane or in spheroidal masses like the zooglœa masses often referred to by Continental writers. Thus it may be seen that any of the cocci under conditions poorly understood may assume this manner of growth. It is probably partly dependent upon their environment and pabulum.

The subdivision of fission fungi which we have herein suggested follows that given by Cohn. By this method the bacilli or desmo-bacteria, are considered as one class separate and distinct from the bacteria proper, or micro-bacteria. There has been a general tendency among writers to classify all organisms in which there is a greater diameter in one direction than in another as bacilli. While there may be sufficient ground for considering them under separate and distinct heads, as far as our purpose is concerned, we being largely interested in the method of classifying by which we can make ourselves mutually intelligible, as well as to simplify, it is perhaps wiser that we consider them both together. Hence we propose to consider bacteria (micro-bacteria) and bacilli (desmo-bacteria) under one head.

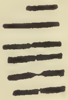
FIG. 4.

Ascococcus. × 800 diam.

When the two divisions were considered separately, the bacilli were described as filamentary organisms, very much longer in proportion to their thickness than the bacteria; the latter also differing from the bacilli in that they had rounded ends.

(2, 3) *Bacilli.* Bacilli usually propagate by fission, although spore formation is not infrequent. Fission, as already described, implies that a single organism has grown continually in its longitudinal axis until it has reached a certain size, at which time it divides into two or more bacilli, as illustrated by Fig. 5. In many bacilli fission may be seen at all stages of their development. By spore formation we mean that a given organism, either with or without very much increase in its longitudinal axis, develops within its cell wall one or more small, highly refractive, and globose or ovoidal bodies, closely resembling cocci. They are retained within the cell wall until their development is complete, at which time the cell wall breaks down and the spores are set free. These spores have many characteristics peculiar to themselves, as, for example, when we consider antiseptics and germicides, we will find that they are very tenacious of life, and that their vitality is but little affected by agents which destroy the mature organism. While many organisms under conditions favorable to growth pullulate by fission, when subjected to adverse conditions develop spores which, in many instances, are practically indestructible by any natural process, as drying, extreme cold, or the absence of any or all forms of nutriment.

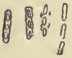
Fig. 5.



Propagation by Fission.

(4) *Spirilli*, or *spiro-bacteria.* These consist of organisms filamentary in character, but coiled more or less, like the turns of a corkscrew. They may be rigid spirals, in which case they are spirilli proper, while if the organism be flexible or a filament, becoming wavy or screw-like upon motion it is known as a *spirochete.* The spirilli grow, for the most part, by fission. In some instances spore formation has been observed. (See Relapsing Fever and Cholera.)

Fig. 6.



Spore Formation. From culture of bacillus megaterium, showing the development of spores within the capsule of the rod, which later breaks up and frees the spores.

Other Classifications of Organisms.

From a clinical standpoint, organisms are presumed to be either productive of disease (*pathogenic*) or they are non-productive of disease (*non-pathogenic*). These are the *pathogens* and *non-pathogens* of some observers. Again, organisms are spoken of as *saprophytic*, or *saprophytes*, by which we mean that they grow upon the surface or on the mucous membranes without giving rise to any distinct disease whatever. To this class, now disproportionately large, probably belong the pathogenic organisms of some diseases in which the presumable microbic cause has not been made out, the saprophytes belonging, of course, to the non-pathogenic bacteria.

There is also a basis of nomenclature founded upon their reaction to air (Pasteur), or rather, in a clearer sense, to the effect of the presence or absence of oxygen. Those organisms living in the presence of oxygen are known as *aërobic*, while those thriving without air, or oxygen, are *anaërobic*. There has been forced upon the bacteriologist two words—unfortunate in some respects—viz., *facultative* and *obligate*. Thus the organism which causes consumption is an obligate aërobic bacillus, while that which causes tetanus has been, until of late, supposed to be an obligate anaërobic organism; but, as shown by Kitasato and Kyle, it grows in the presence of oxygen, though best when this element is absent; it is a facultative anaërobic bacillus. As some organisms produce color, they are called *chromogenic*.

The microbes which produce pus are known as *pyogenic* organisms, and may be either facultative or obligate in their action. Thus the bacillus coli communis is not ordinarily pus-producing; it may, however, do so, under which circumstance it becomes a facultative pyogenic organism. Other methods of nomenclature will be often met with, but, for the most part, they explain themselves.

The methods by which micro-organisms produce disease are two, (1) *By direct invasion*, (2) *The chemical products* of the bacteria may be causative factors. As an example of the former, we have the plugging of the blood-vessels, as in anthrax, while of the latter, we have the symptoms of tetanus due to the ptomaïnes or alkaloids produced by the bacillus.

A large number of diseases are *a priori* of microbic origin, although no specific organism has as yet been isolated. In the following list we endeavor to deduce the extent of the relation subsisting between organisms and disease:—

Actinomycosis. Actinomyces, or ray fungus. Pyriform or club-shaped elements arranged in rosette forms, and hence named " Ray fungus."

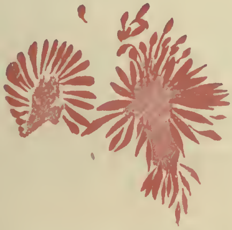
Anthrax. Bacillus anthracis (Davaine). A rod-shaped organism 1 to 1.5 μ thick and 5 to 20 μ in length. Develops resisting spores. Causes a disease known as splenic fever in animals and malignant pustule in man. Wool sorters' disease is one form of the affection, so named from the source of the infection. (See article on " Meat Inspection.")

Anthrax, Symptomatic. (See article on " Meat Inspection.")

Bronchitis, Acute. Osler regards the condition as "probably microbic," while many retain the opposite view. This does not refer to those forms due to irritants.

Acute Catarrhal Conditions Affecting the Gastro-intestinal Mucous Membrane. These are not infrequently due to the ingestion of bacteria and their products, the latter, no doubt, being the more active agents.

Fig. 7.



Actinomyces (Ray Fungus).
× 800 diam.
From bovine actinomycosis.

Fig. 8.

Bacillus Anthracis.
× 800 diam.
Composite field showing single bacilli, also a chain, and filaments undergoing spore-formatin. From cultures.

Cerebro-spinal Meningitis. Presumed to be due to an organism; various forms have been found associated with the disease. The lance-shaped coccus of Pasteur has been most commonly observed.

Varicella, or Chicken-pox. Presumed to be caused by a germ, but no trustworthy observations have been made except in the negative.

Cholera asiatica. Spirillum cholera (Koch). Spiral-shaped organisms usually growing as short, slender, comma-shaped rods, hence the name comma bacilli; they possess flaggelli.

Supposed to show spore formation. Causes Asiatic Cholera in man, usually gains ingress to the body by ingestion, spreading originally from other cases of cholera.

FIG. 9.

SPIRILLUM CHOLERA ASIATICA. × 800 diam. From culture. Single comma-shaped organism, others joined in chains and in S-shaped threads.

Membranous Laryngitis, or Croup. The intimate clinical relation of this disease to diphtheria has rendered its microbic orgin most probable The intimate connection subsisting between membranous croup, laryngeal and other forms of diphtheria, and Löffler's bacillus has led the majority of the profession to consider the bacillus the etiologic factor in all.

Dengue. McLaughlin, of Texas, has found in the blood of patients a coccus which Osler regards as "streptococcus-like." Its exact causative relation to the disease is still a question of dispute.

Diphtheria. Bacillus diphtheriæ (Löffler-Klebs). Rod-shaped organism, in length about 2 to 4 μ, and twice the width of a tubercle bacillus. Causes diphtheria in man, also in rabbits and other lower animals.

FIG. 10.

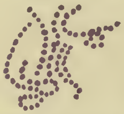
BACILLUS OF DIPHTHERIA. × 800 diam. From culture.

Dysentery, Epidemic. Is usually associated with conditions favorable to the theory of a microbic cause or a ptomaïne poisoning. Conclusive evidence is, however, wanting.

Endocarditis. Microbic causes have been presumed to exist.

Erysipelas. Streptococcus pyogenes (Rosenbach) vel erysipelatis (Fehleisen). This organism was, at one time, believed to be two distinct members of the cocci group, but now observers are fairly well agreed that the two discoverers have found one organism under differing conditions. It is undoubtedly one of the causes of suppuration, and is the specific cause of erysipelas. It develops constantly as a chain coccus, dividing in two directions not infrequently, thus giving the idea of a chain of diplococci. It is very variable in size, and different sizes may be found in the same chain.

FIG. 11.



STREPTOCOCCUS ERYSIPELATIS. × 800 diam. From culture.

Erysipelatous Fever, or Black Tongue. Probably of microbic origin, although no evidence has been adduced sufficiently strong to make it positive.

Erythrasma, Pinta Disease. This and a few other similar pigmentary diseases of the skin due to organisms have been described in the tropics. They are rare in this country.

Favus. A disease of the skin imported into this country from Europe, and contagious from contact. It would appear that dirt is necessary to its inception, as cleanliness seems to remove the likelihood of its spread. It is due to the Achorion schōnleinii, a fungus belonging to the erysiphe group.

Fig. 12.

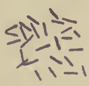
Favus. × 800 diam (from a mouse). *a.* Germinating tube from gelatin culture. *b.* Conidia. *c.* Formation of fruit. *d.* Mycelium threads with fructification.

Fig. 12, (*a*).

Favus from agar agar culture.

Glanders, or Farcy. Bacillus Mallei (Löffler and Schütz). Rod-shaped organism about the size of the bacillus tuberculosis; the ends are more rounded, and it reacts differently to stains. Causes glanders or farcy in horses, from which the disease has been communicated to men.

Fig. 13.



Bacillus Mallei (Glanders). × 800 diam. From culture on potato.

Fig. 14.

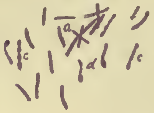
Diplococcus of Gonorrhea (Gonococcus). × 800 diam.

Gonorrhea. Gonococcus (Neisser); Micrococcus or Diplococcus of Gonorrhea. A diplococcus constantly present in gonorrhea.

Influenza, or La Grippe. Highly infectious. Microbic origin probable.

Leprosy. Bacillus Lepræ (Hansen). Rod-shaped organism closely resembling the bacillus of tuberculosis. Causes Leprosy and is considered diagnostic of the disease.

Fig. 15.



Bacillus of Leprosy. × 800 diam.
a. Mature bacilli. *b.* Bacilli containing spores. *c.* Beaded appearance of the bacilli. *d.* Curved or club-shaped bacilli.

Malaria. The Bacillus malariæ of Klebs and his contemporaries has not been accepted, and at present the disease is presumed to be due to the parasitic organisms of Laveran, which belong to a group of parasites known as hematozoa, members of the protozoa.

Malta Fever, or Rock Fever. Bruce has described a micrococcus as present in the spleen, but the entire subject of its etiology is *sub judice.*

Rubeola, or Measles. Contagion not known. Many organisms have been described, but as yet none meet the requirements of Koch's law.

Epidemic Parotitis, or Mumps. The infectious agent is not known. The various organisms found have not been thoroughly investigated.

Mycetoma, or Madura Foot, also known as the Fungus Foot. The close analogy subsisting between this disease and actinomycosis would incline one to believe the exciting cause some cognate organism. Vandyke Carter has described a fungus as present in these cases. However, as Lewis, Cunningham, and Tilbury Fox have failed to identify the fungus, the matter may be still considered *sub judice.*

Pleurisy. The diplococcus of Frænkel has been shown to have a certain causative relation to this disease.

Fig. 16.

Diplococcus Pneumoniæ. × 800 diam.

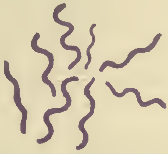
Pneumonia (Croupous). Diplococcus pneumoniæ (Frænkel). In the lung and sputum it is usually within a capsule, which is lost by cultivation. (Note.—From some experiments carried on in Dr. Coplin's laboratory by Dr. Gilbert, of Georgia, we are convinced that the microbic theory of Pneumonia is still to be settled by further investigation).

Pyemia. This disease is now known to be due to a mycotic invasion of the blood by the organisms which produce pus. It is possible that there are other forms which gain ingress at the same time; this, however, is not settled.

Rabies or, Hydrophobia. The possibility of this disease being due to bacteria is admitted, but as yet sufficient evidence has not been adduced.

Relapsing Fever. Spirochæte obermaieri (Obermaier). Flexible filamentary organism present in the blood of patients having relapsing fever. It is present only during the relapse.

FIG. 17.



SPIRILLUM OF RELAPSING FEVER (Spirochæte obermaieri). × 800 diam.

Rheumatic Fever, or Acute Rheumatism. Probable microbic origin has been brought forward, but no germ has as yet been definitely presented as the cause.

Rhinoscleroma. Bacillus of Rhinoscleroma. (Cornil and Alverez). Short rods 1.5 to 5 μ in length and .5 to .8 μ thick. Spore formation doubtful.

The Various Forms of Ringworm. Due to the invasion in the skin in different localities by the Tinea trichophytina or Trichophyton tonsurans. There is also a form of ringworm usually imported from the tropics and due to the Tinea imbricata. It would appear from the description usually given of this disease that certain climatological factors are necessary for its development. The contagiousness of the disease diminishes as we approach from tropical to temperate climates and is unknown in the colder regions.

Sapremia. This disease is due to the absorption of ptomaïnes produced by some of the many forms of organisms. Usually it is a surgical disease, but identical symptoms have manifested themselves after swallowing mixtures containing bacteria or their products. Notably has this been the case in drinking water heavily charged with sewerage, several deaths having been traced directly to this source.

Scarlet Fever, or Scarlatina. Specific microbe not yet isolated. There is a presumed relation between the throat condition and the bacillus of diphtheria. A streptococcus has been observed in the blood, lymphatic glands, and kidneys.

Septicemia. As in Pyemia, this disease is due to bacteria thriving in the blood and producing ptomaïnes, which give rise to the symptoms. No specific organism is known to exist.

Gangrenous Stomatitis, or Cancrum oris, or Noma. Presumed microbic origin, not yet known. Lingard's bacillus is considered by Osler as of doubtful significance.

Parasitic Stomatitis, or Thrush. This disease is produced by a fungus belonging to the saccharomycetes and known as S. albicans; by some authors as Oïdium albicans.

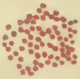
Fig. 18.

Saccharomycetes (Oïdium) Albicans, or Thrush Fungus.

Ulcerative Stomatitis. Possible microbic origin. Relation to foot and mouth disease not entirely proven.

Suppuration. Micrococcus pyogenes aureus (Rosenbach). Chromogenic micrococci .8 μ in diameter. Developing an orange-yellow color in culture. Micrococcus pyogenes albus, same general description as above, except that the culture growth is white. Micrococcus pyogenes citreus. Same as above, except that the color in culture is a citron yellow. Micrococcus cereus flavus and micrococcus cereus albus (Passet) have also been identified as present in pus. (See erysipelas.) There are other organisms which are facultative pyogenic bacteria.

Fig. 19.



Micrococcus Pyogenes Aureus. × 800 diam.

Syphilis. Bacillus of Syphilis (Lustgarten) is a rod-shaped organism resembling very closely the organisms found in leprosy and tuberculosis. Spore formation not as yet determined. The question of its pathogenesis may be considered as thoroughly established.

Tetanus. Bacillus of Tetanus (Nicolaier). Rod-shaped organism developing endospores giving it the appearance of a drumstick. Found largely in earth.

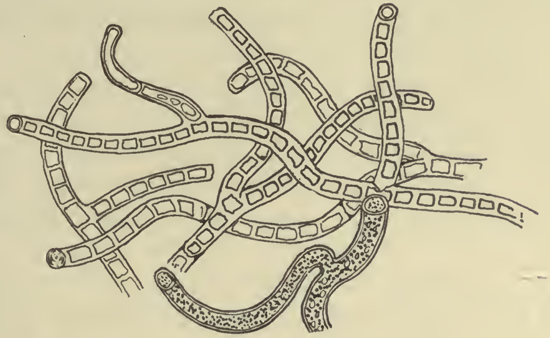
Fig. 20

Bacillus Tetani. × 800 diam.

a. Spool-shaped bacilli. *b.* Chain of bacilli. *c.* Clubbed bacilli with spore at one end. *d.* Clubbed bacilli without spore *e.* Spindle-shaped bacilli with spore in center. *f.* Free spores.

Tinea versicolor. This disease is due to a vegetable parasite known as the Microsporon furfur.

FIG. 21.



MICROSPORON FURFUR (TINEA VERSICOLOR). × 600 diam.

Tuberculosis (*Consumption*). Bacillus tuberculosis. A rod-shaped organism very thin and from 2 to 4 μ in length. Spore formation not as yet fully established, although probable. Causes consumption and tubercular processes in the glands, joints, bones, etc. It is abundantly present in the sputum of patients suffering from tuberculosis of the lungs. The spread of all forms of tuberculosis is undoubtedly due to this organism.

FIG. 22.

BACILLUS TUBERCULOSIS. × 800 diam.

Typhoid, or Enteric Fever. Bacillus typhosus (Gaffky). Rod-shaped organisms 1 μ in width and 2 to 4 in length, occasionally forming filaments 50 μ long. Organism supposed to be flagellated. Spore formation not proven. These bacilli produce Typhoid Fever, and under certain conditions have been able, it is presumed, to produce suppuration. Usually gains ingress from the dejecta of other cases of typhoid fever, through milk, water, dirty clothes, possibly by the air.

FIG. 23.

BACILLUS TYPHOSUS. × 800 diam.

Oriental Plague. Under the varied names of "the black death," "bubonic plague," miserial morbis, and Oriental plague, there has existed in the East a most fatal disease, which, from the historical and modern accounts, answers all the requirements usually present in highly infectious microbic maladies. The disease is unknown in America, but as late as 1885 it has threatened the invasion of Europe.

Sweating Sickness. An epidemic infectious disease about which little is known; may, indeed, probably does, belong to the microbic diseases.

Typhus Fever. Strepto-bacillus (Hlava). Has not as yet been thoroughly investigated. The highly contagious character of the disease makes its microbic origin probable.

Variola, or Smallpox. Specific virus unknown. Micrococci of suppuration have been noted as constantly present in the pustules.

Vaccinia Vaccination. Microbes presumed to be the active agents. Quist, and Ernest, and Martin, of Boston, have isolated and cultivated cocci, which when inoculated in children produce a typical vesicle.

Whooping Cough. Presumed to be caused by some form of microörganism, but proof is wanting. Afanassjew's bacillus probably deserves a closer study than has yet been given it.

Yellow Fever. Of the many organisms presumed to be present, none have withstood the test of experimentation.

To the above list might be added some rare diseases, presumably due to microörganisms, and experimental diseases produced in the laboratory, but rarely, if ever, to be seen in man. It is needless to say that in the present state of our knowledge but few diseases exist in which microbic causes seem probable, that have not been as fully investigated as their prevalence would permit.

Ptomaïne Poisoning.—Not only have bacteria a definite relation *per se* to the production of disease, but the products of bacteria, ptomaïnes, are actively disease producing; indeed, it seems highly probable that these are, almost exclusively, the agents upon which the symptoms and lesions depend. For the most part, we are interested in those forms, ingestive in mode of invasion, usually due to decomposition of some of the foods. Meat, in the large majority of cases, is the infective or carrying material. Cases of poisoning by meat pie, sausage, and similar cooked and uncooked animal compounds have long been known as occasionally inducing toxic conditions; it is, however, only recently that ptomaïnes have been brought forward as actively etiologic factors.

These poisons act either as irritants to the alimentary canal or by toxic effect upon the circulatory, respiratory, or nervous systems. Some members of this group of alkaloids have been studied with great care, both at home and abroad. Vaughan and Novy have gone into the subject most fully, and any one desirous of obtaining a complete knowledge of the subject will do well to consult their work. These gentlemen have interested themselves more particularly in the direction of cheese, milk, and ice cream, bringing forth their discovery of tyrotoxicon, to which, as they point out, has been due many of the fatal poisonings. The exact cause or causes which lead to the production of tyrotoxicon have not, as yet, been ascertained. This subject will again be considered when we take up food.

Animal Parasites.—Disease may be produced by parasites belonging to this group. For the most part, their action, so far as known, is purely mechanical. Unlike bacteria, we are not aware of any chemical products engendered, and their methods of producing disease depend almost entirely, if not exclusively, upon mechanical interference with function, or the induction of inflammation by invasion, either directly or indirectly. The following are the most important:—

Keratosis follicularis, Paget's Disease of the Nipple, Cancer (*?*) The sporozoa are minute animal parasites of the lowest order or division of protozoa. As a rule, they enter the organism with the food and eventually are found in the liver. Although sufficient evidence is at hand to demonstrate their causative relation to certain processes, we are not in a position at present to give a distinct clue as to their source.

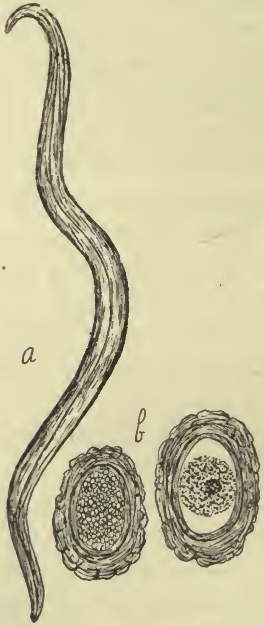
Osler refers to cutaneous Psorospermiasis, including under this head Keratosis follicularis and possibly Paget's disease of the nipple. An organism brought forward by Russell as constantly associated with cancer probably belongs to this group.

FIG. 24.

DISTOMA HEPATICUM.

Flukes, or Trematodes. These parasites rarely cause disease in man. They infest either the alimentary canal or its appendages, less commonly the blood. Diseases due to flukes are not common in this country, they being, for the most part, found among the inhabitants of the East. Invasion is probably brought about by infection through water containing the ova. Little, however, is known of their life history, and when we take into consideration the large amount of unpotable water annually consumed, with the inevitable quantity of animal parasites or their ova, we cannot doubt the possibility of many obscure cases being due to some of the forms of distomiasis.

FIG. 25.



ASCARIS LUMBRICOIDES AND EGGS.

FIG. 26.

OXYURIS VERMICULARIS.
a. Female. *b.* Male.

Ascaris lumbricoides. Ascaris lumbricoides, or round worm, infests the intestine, although it may wander into any of the passages which open into the alimentary canal, *e. g.*, the bile duct, larynx, etc. The male measures about four to six inches in length, the female, seven to ten; color yellowish-brown or pale reddish-yellow.

Oxyuris vermicularis. Oxyuris vermicularis, or thread-worm. This parasite derives its name from the close resemblance which it bears to a thread of fine sewing cotton. The female is scarcely half an inch and the male one-fourth of an inch in length. Ingress is probably attained through food and drink.

Tricocephalus dispar. This unimportant parasite measures from one to two inches in length, the female being the larger. They are easily differentiated from the Oxyuris by their anterior extremity being extremely thin, while the body thickens as we progress toward the posterior termination, which is blunted.

Trichinæ spiralis. A well-known disease, trichinosis, is produced in man through the invasion of the muscular system by the embryo of the intestinal parasite. These are better shown in the cut than can be here described. (See illustration in meat inspection). Trichinæ are derived almost exclusively from the hog, although they are to be found in cats, rats, mice, moles, and other lower animals.

Dochmius duodenalis. Dochmius, or strongulus duodenalis, is a parasite found chiefly in the jejunum of man. Ingestion occurs through water. The different forms of anemia known as brickmaker's, tunnel, and mountain anemia are due to this parasite, as is also Egyptian chlorosis.

Filaria sanguinis hominis. A parasite which in the adult state is found in the lymphatics. It produces hematochyluria, elephantiasis, and lymph-scrotum. It is extremely minute in its transverse diameter, not over one-hundredth of an inch, and measuring from two to three inches in length. The filariæ are most common in tropical countries, and their ingestion occurs, most probably, through water. The ova, cast in circulation, are probably extracted by the mosquito, in which possibly some development takes place, the final lodgment occurring by the death of their host.

Filariæ, Other Forms. Other forms of Filariæ are: *F. Dracunculus medinensis*, or *Guinea-worm*, *F. loa*, *F. lentis*, *F. labialis*, *F. homini oris*, *F. imitis.* Invasion occurs through impure water.

Rare Parasites. Eustrongylus gigas, *Rhabdonema intestinale*, are parasites which have occasionally been seen in man.

Tenia mediocanellata. Tenia mediocanellata, or beef tapeworm, a parasite found in the intestines varying greatly in size.

Gains ingress through the eating of uncooked beef containing the embryo. (See *Meat Inspection.*)

Tenia solium. Tenia solium is derived from the hog, in which it exists as small ova or cysts, which, if not destroyed by cooking, give rise to adult worms, differing from the Tenia mediocanellata in that it is usually solitary and has its head surmounted by a circle of hooklets. Pork containing these cysts is known as "measley pork." (See article on Meat Inspection).

Cysticercus cellulosæ. The larva of the Tenia solium is known by this name. When the larvæ gain ingress to the stomach, either by ingestion with the food or regurgitation from the intestine, they penetrate the muscular wall and give rise to cysts in various parts of the organism. (See *Meat Inspection.*)

Echinococcus, or Hydatid Disease. Echinococci, or hydatid worms, are the larval forms of the Tenia echinococcus of the dog, and usually gain ingress to the organism by ingestion. The disease is rare in this country. (See *Meat Inspection.*)

Bothriocephalus latus. A tape-worm, rare in this country, presumed to develop in certain fish; this, however, is not positively known.

Parasitic Arachnida. Pentastomum tenioides, a lancet-shaped parasite observed in the nostrils and frontal sinuses of the dog, more rarely in the horse.

Pentastomum denticulatum may rarely be the occasion of inconvenience.

Pentastomum constrictum has been observed by Aitken in the liver and lungs.

Demodex (Acarus) follicularum (rare) infests the sebaceous follicles in sufficient numbers to give rise to inflammation or acne.

Acarus (or Sarcoptes) scabiei, or itch insect. This is the most important of the Arachnid parasites and infests the skin, giving rise to well-known and troublesome lesions.

Ixodes ricinus, or wood tick, is a parasite occasionally found upon dogs and other lower animals.

Leptus autumnalis. This is a harvest mite. Although it is extremely small, it can be readily seen on account of its red color. It gives rise to the formation of slight skin lesions which are, however, not constant. There are two American species which are very closely allied, the Leptus americanus and the Leptus irritans.

Parasitic Insects. Pediculus capitis, or head louse. This parasite or insect is found more particularly upon the head, where it burrows in the scalp, from which it sucks blood for its nourishment. The eggs or nits are deposited upon the hair, to which they are attached by a chitinous covering. The young louse hatches in from eight to ten days or possibly less.

Pediculus pubis, or crab louse, is an inhabitant of the hairy parts of the body, more particularly the axilla and the external genitalia. It is smaller than the head louse and more difficult to detect.

Pediculus vestimentorum, or body louse, is found in the clothing, usually in the neighborhood of seams and crevices, in which it may hide and deposit its eggs. It feeds off the body, which it visits for that purpose. It is somewhat larger than the Pediculosis capitis.

Cimex lectuarius, or bed-bug, infests bedding, old floors, walls, closets, bedsteads, etc. This insect visits the human victim in order to suck blood ; its visitations are usually at night, although not necessarily so, as individuals sleeping in the daytime will be just as much annoyed as at night.

Pulex irritans, or common flea, most commonly found on the hog and dog, may be a parasite on the human. Its eggs are laid in the floors, in sawdust, leaves, dry hay, etc.

Pulex penetrans, or sand flea, also known as jigger, is found in the sands of South Africa and in the southern parts of this country.

THE PREVENTION OF DISEASE.

There are two methods which may be available for the prevention of disease, the first to be spoken of as general means, and the second, special. These may be aptly illustrated by comparing disease to a fire, in which we take certain general means to render the building fire-proof, and, second, when the fire seems impending, means are brought to bear in order to prevent the fire attacking the building. Under the head of general means we have to consider the individual and the maintenance of his physical condition in that state which renders it improbable that disease will gain ingress. This probably belongs to the consideration of individual hygiene, and will be considered separately. Aside from the general applications which are to be considered as applying to everybody, there are individual applications which are to be considered; for example, in speaking of tuberculosis, we referred to the fact that the disease seemed to select those individuals possessing a hereditary proclivity or peculiarity of tissue or structure which affords a suitable nidus for the development of tuberculosis. Herein we have one element of a cause which in all probability is necessary, at least in many diseases, to demand a superadded or second or even third element before the disease will actually develop; hence, if we can prevent the occurrence of either one or the other element or cause, or if we can modify the existing element or cause, we may be able to prevent the development of the disease. Thus, in tuberculosis, intermarriage between members of tubercular families should be, by every possible means, discouraged, as the offspring will inevitably inherit the proclivities transmitted by the parent. Unfortunately, the physician rarely has this matter under his control. It behooves us, however, to be vigilant, and exercise every effort for the furtherance of the public good, no matter how ineffectual our efforts may prove.

Secondly, where there is a tendency toward the development of any disease, the environment of the individual should be such as not to expose him to the dangers of that disease. Where there are reasons to believe that the child has inherited a tubercular tendency, its school life in the earlier years and its college life in the later years should be so modified as to diminish to a minimum all those dangers arising from confinement, want of pure air and out-door exercise; and when that same individual comes to select a calling, occupation, or profession, it should be of such a character as to again preclude all those elements so well known to be associated with the development of tuberculosis; further than this, such an individual cannot risk association with similar individuals, and his continued health and well being will depend upon the perpetual vigilance which he exercises in excluding himself from all surroundings and all associates, as far as may be possible, where the ingress of any of the second causes may be found. Aside from these general means, special methods are to be considered for the prevention of individual diseases, either alone or in groups. Thus, the malarial diseases may be driven from the locality by proper drainage and appropriate agricultural pursuits. Certain groups of the diseases are to be combated with upon certain definite principles. Thus, the spread of contagious diseases is to be prevented by *quarantine*, *depopulation*, *isolation*, or *segregation*, *vaccination*, and *disinfection*.

Quarantine, Isolation, and Segregation.

These are peculiarly applicable in diseases whose development depends entirely upon the transmission of cause from individual to individual, whether direct or through some medium. The fact that the disease may be readily spread through transportation by clothing or any other material which has come in contact with the disease primarily, and secondarily with an individual susceptible to the disease, renders isolation necessary.

Quarantine, as originally used, implied a detention of forty days (It., Quaranta). The term is now intended to mean the detention of carriers of infective material, arriving from an infected port, in order to determine whether infection be present, or a detention to disinfect material known to be infected. The term is at present more or less closely related to the term isolation. Isolation is used to indicate the separation of an infected individual, or an individual presumed to be infected, from those likely to suffer from infection, or the reverse. Segregation is a term applied where individuals are set apart on account of some infectious disease which is likely to detain them for an indefinite period. It is isolation practically on a larger scale. As examples of these three conditions, one may consider a vessel detained from an infected port as being in quarantine; a child suffering from scarlet fever is isolated from its playmates or the other members of the family; leprous individuals are segregated in colonies.

It will probably answer our purpose if we describe the isolation of an individual; for whatever applies to an individual is equally applicable to individuals in the aggregate. Isolation should imply not only separation of the sick from the well, but more properly the well should be removed from the sick; thus, in a case of smallpox, it is highly inexpedient to remove the victim and then permit the well to inhabit the room before thoroughly disinfecting it. The writers are quite confident that they have seen this mistake made. Contagious diseases are not uncommonly discovered in that stage when their contagion is most active, at which time the physician orders the carpet removed from the room, the windows dismantled of their curtains, all ornaments carried out of the room, and the room left bare. Nine times out of ten this means merely conveying the contagion-carrying material out for dissemination, and leaving the patient, who is already infected, in the room where infection is none the less likely to occur. If we could remove all the material before the disease develops, or if the disease developed in a bare room, it would be a great deal better, but it does not lessen the danger to remove the draperies after the disease has developed. Their removal is desirable by reason of the fact that the longer they are in the room the more difficult will be their disinfection and the greater the danger in their removal.

Where it can be prevented, the individual to be isolated should not be imprisoned. The very best hygienic surroundings attainable should be placed at the command of the sick, for it is definitely proven that epidemics are aggravated and contagious diseases rendered more virulent by bad hygiene. Having selected a good, airy room, where ingress and egress are direct from the outside and not through a room or hall, or, if this be not attainable, a room as high in the house, and as far from the inhabited quarters as can be had comes next in preference, we come to the consideration of other matters pertaining to isolation. Absolutely nothing should be carried into the room which is not a matter of necessity; napkins with the food, towels, extra bed clothing, etc., should be strictly interdicted. All clothing for the patient when once in the room should not be allowed to come in contact with any individual except the attendant, nor should any such articles be used about the house, or even carried out of the room, without having been thoroughly disinfected, a process which we will consider later.

There are three periods at which quarantine or isolation or segregation may be applicable: First, during the period of incubation, that is, from the time the individual is exposed to the disease until the disease either develops or a sufficient period has elapsed to render it reasonably certain that the individual is not suffering from a contagious or infectious disease. Second, during the time when the individual may be suffering from a contagious or infectious disease. Third, the period following the disease, while the individual is still in a condition liable to transmit the infectious material to others. Thus in smallpox and scarlet fever, for a considerable length of time after the symptoms of the disease have for the most part disappeared, there still remains the danger of infection, in the first instance from the scabs still adhering to the surface, and in the second from the scaling of the epidermis which follows the scarlatinal rash. It matters little in which stage it has been necessary to detain the individual, at the termination of such detention disinfection should always be thoroughly carried out. There is reason to believe that the individual detained through the presumed period of incubation should have the person and all clothing subjected to rigid disinfection, as he may be the carrier of disease, although not himself suffering; and in order to make assurance doubly sure the disinfection should take place prior to detention and again before release. The time necessary for detention varies greatly with different diseases and also at different times in the same disease. By reason of these variations, it is necessary, where arbitrary rules are to be laid down, to err on the safe side and make the detention extremely prolonged; it is safer, better, and more just to the individual and to the community to detain ten days over the extreme limit of probable infection, than to release the individual ten hours before the impending outbreak of the disease occurs.

Objections to Quarantine. The objections to quarantine lie largely in the fact that as managed under ordinary conditions, it is inefficient, unreliable, and unsatisfactory. There are so many things which either directly or indirectly counteract the beneficent influence of quarantine that not a few sanitarians now discourage it. Navigation and railroad companies use all possible influence to escape the expense incident to quarantine. Personal friendship and political pull strain every effort to prevent the vicissitudes incident to detention; add to these the individual prejudice against detaining the healthy, the sick, and the convalescent, each offering excellent excuses to evade quarantine, and we have a wave of power and influence by which the most rigid sanitarian will, at times, be overcome.*

It may be largely maintained that the objections above pointed out are due to the faulty method and indifferent officering of sanitary powers, but while man is human and the existing difficulties endure, these objections will probably be maintained, and with more or less justice.

There have been no well-founded objections raised to isolation and segregation, as in leprosy, and as must be sooner or later in syphilis and tuberculosis, when the protection of the community shall be demanded by its individual members.

The *duration of isolation* varies in different diseases, and as this is a matter of vast importance, we will now proceed to consider it more or less in detail. What diseases do and what do not demand quarantine or isolation is a polemical subject; and we content ourselves in prescribing rules for the guidance of physicians which, if they err, err on the side of safety. We do not consider that chicken-pox demands isolation ; however, there may be children in the house whom, either on account of weakness, debilitated health, or some existing disease, it may be important to protect from infection. During epidemics of smallpox, isolation may be necessary for diagnostic purposes.

In many of the States and cities different diseases are considered as contagious and dangerous, and often it is necessary to isolate very simple diseases in order to satisfy the community and, in no small number of cases, badly constructed laws and Board of Health regulations. While considering the isolation of diseases, we are to remember that occasionally it will be necessary to isolate healthy individuals ; for example, where parties are leaving an infected area, or where an individual has been exposed to the contagion of some epidemic disease, it may be necessary to confine him for a certain period in order to ascertain if he be infected. This period, from the time of expo-

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* During the recent threatened epidemic of cholera in Philadelphia (1892), a member of the Board of Health of the City of Philadelphia, on his own responsibility liberated one of the passengers. Fortunately, nothing occurred, but had cholera been aboard and the man exposed to the disease, the community was in as imminent danger as though the whole ship-load had been liberated, the difference being only in degree.

sure to the appearance of symptoms, is known as the period of incubation, and can only be approximately estimated, as there seems to be sufficiently well-marked differences in individuals as to the length of time which a disease incubates. The estimate given herein is sufficiently wide, it is believed, to allow for such variations.

Actinomycosis. All animals suffering from the disease should be killed and the carcasses incinerated. In man such isolation as is compatible with his surroundings should be established. There is evidence to believe that the sputum may communicate the disease, and hence the necessity of its disinfection. Nothing is known of the incubation period in actinomycosis.

Anthrax. Animals suffering from this disease should be slaughtered and their bodies incinerated. Animals exposed to the contagion should be quarantined. The strictest regulations should be established in order to prevent the skin, horns, wool, or any part of the animal from becoming articles of traffic. In man the greatest care is demanded concerning all excreta, dressings, clothing, etc. Thorough isolation should be imperative. As the microörganism which causes this disease is one of the hardest to kill, no germicide short of the very highest attainable temperatures should be trusted, and hence absolute destruction of everything likely to prove infectious must be demanded.

Cerebro-spinal Meningitis. Careful isolation in large, airy rooms. Disinfection of all material coming from the patient. Isolation should be maintained long into convalescence and followed by thorough care in bathing. Disinfection of all clothing, beds, etc. The incubation period is unknown.

Varicella, or Chicken-Pox. Under ordinary conditions this disease does not require isolation, on account of its extreme mildness and the unlikelihood of its giving rise to any serious complications. However, during an epidemic of smallpox all cases of varicella should be treated exactly as varioloid. This is necessary on account of the extreme possibility of smallpox being mistaken for chicken-pox. The period of incubation is from ten to fifteen days. Cases should be isolated for not less than nineteen days.

Cholera, Asiatic. Thorough and careful isolation of the patient. Disinfection of all dejecta, soiled linen, and everything which comes in contact with the patient, careful investigation as to the presumed source of the infection, including the examination of water supply, sewerage, drainage, plumbing, etc. The period of incubation in cholera varies more than in other common epidemic diseases. Some writers state that it may come on in a few hours, others in from a week to ten days. If an individual who has been in the cholera district is free from the disease three weeks after leaving the infected area, the probability of his taking cholera may be considered as *nil.* As it is probable that a normal acid condition of the stomach lessens the tendency to the inception of the disease, great care should be exerted among the healthy to maintain perfect digestion; slight diarrhea should have prompt attention, the sale of fruits should be restricted, and the sanitary condition of the towns and cities raised to the highest possible standard. All food, including water, should be cooked before its ingestion; the greatest care should be manifested in the inspection of milk, by reason of the extreme liability for dealers to adulterate with water which may be infected.

Membranous Laryngitis, or Croup. The infectious character of this disease and the difficulty in differentiating between it and diphtheria is so great, that it demands the same sanitary precautions. (See Diphtheria.)

Dengue. The contagiousness of this disease has not been entirely settled. Isolation should, however, be insisted upon and continued, in large, airy rooms, until convalescence is well established. By some municipalities the disease is quarantinable, and, as the infectious element is not known, disinfection of all materials likely to be the source of contagion should be insisted upon. Period of incubation three to five days.

Diphtheria. Isolation until after all throat symptoms have disappeared. Care as to the disinfection of all materials coming from the isolated room, exclusion of all communication between the cases and children, or even adults. Diphtheria in a house should demand careful inspection of all plumbing, sewerage, ventilation, and possible accumulation of decomposing matter of any kind. Disinfection of all rooms, clothing, bed, etc., necessary. The period of incubation is from two to four days in some epidemics, to ten or twelve in others.

Dysentery. Should dysentery become epidemic a thorough investigation should be made into the water, milk, and vegetable supply. Disinfection of intestinal dejecta. Incubation dependent entirely upon the severity of the poison.

Erysipelas. Medical cases evince but slight tendency to spread. In surgical cases it must be thoroughly isolated and all possible avenues for conveyance closed. Disinfection of dressings, rooms, furniture, bedding, etc., necessary. Incubation three to seven days.

Epidemic Erysipelatous Fever. Isolation should probably be resorted to. Disinfection of all clothing, beds, etc. Flint is of the opinion that its contagiousness cannot be considered as established; in the absence of positive knowledge the disease should be considered as feebly contagious. The period of incubation is not certain, and probably varies from five to nine days.

Glanders. As this disease is nearly always communicated to man from the lower animals, its prevention lies largely in the killing and destruction of infected animals. Should the disease arise in man, he should have exactly the same hygienic consideration as already pointed out under actinomycosis. Incubation in the acute form from three to four days. Nothing is known as to the incubation of the chronic form.

Influenza. The method of spread in this disease is very obscure. However, quarantine against its invasion has been successfully maintained. The period of incubation varies from a few hours (?) to three or four days.

Leprosy. Segregation of the leprous is demanded. Marriage should be positively prohibited. Disinfection of all materials coming in contact with the patient must be insisted upon. Good hygienic surroundings and scrupulous cleanliness apparently limit its spread.

Malta Fever. Depopulation of the infected area, isolation of the cases, abundant ventilation, and, although the contagiousness is still a matter of greatest doubt, the disease is to be so considered, to a feeble degree. Incubation period lasts until some time into the second week.

Rubeola, or Measles. Isolation until all evidence of the eruption has passed away. The disease is usually so mild as to rarely demand any special quarantine consideration. As the disease has been conveyed in clothing, disinfection of all materials coming in contact with the disease is demanded. The limits of incubation are variable, from seven to twenty days, usually about ten days.

Epidemic Parotitis, or Mumps, is so extremely mild that isolation under ordinary circumstances is not to be thought of. If, however, it should be deemed necessary the disease is to be treated exactly as other contagious diseases, isolation being maintained long into convalescence. The period of incubation varies from five to twenty days, rarely longer.

Relapsing Fever. Careful isolation in large, airy rooms, with abundant ventilation, as it is probable that the breathing and cutaneous exhalations communicate the disease. It does not seem evident that the intestinal dejecta contain the poison, nevertheless, they should be treated as elements of danger until our knowledge on the point is more definitely settled. The period of incubation varies from three to twelve days; usually the disease manifests itself from the fifth to the seventh day. As relapses occur as late as the fortieth day, the after detention must of necessity be prolonged in order to establish positive knowledge of complete recovery.

Scarlatina, or Scarlet Fever. Thorough isolation and greatest possible care as to transmission by carrying from the sick to the well through the carelessness of the parent or friends. The isolation should last from three to five days after all desquamation has ceased. The patient should then be given a bath, followed by disinfection of the skin, and removed from the room, which is to be thoroughly disinfected, including bed-clothing, clothing, furniture, walls, etc. As the desquamating epithelium retains the contagious element, great care should be maintained until the process is completed. The period of incubation is from three to fourteen days.

Parasitic Stomatitis, or Thrush, Noma, or Gangrenous Stomatitis. Cases should be prohibited all association with other children. Greatest care should be used to see that the feeding utensils, either knife, fork or spoon, or nursing bottle, should not come into use by any other individual. Disinfection of stools, clothing, feeding utensils, etc. Nothing is known of the period of incubation.

Tetanus. As tetanus ordinarily occurs in private families, isolation is not necessary, but in armies and where there are collected individuals suffering from wounds and other surgical diseases, tetanus should be kept apart and the greatest possible care exerted to restrict or limit its spread. Disinfection of all dressings, bedding, clothing, instruments, etc., should be thorough, before allowing them to come in contact with another patient. A special nurse should be assigned the case and allowed to attend no other. Incubation, ten to fifteen days.

Tuberculosis Pulmonalis, or Consumption. This widespread disease demands great care for its prevention which we cannot in the present condition of the public mind apply. Marriage of tuberculous individuals should be prohibited and association with the healthy rendered impossible. Disinfection of all sputum while it is in the moist state and destruction of all materials with which it comes in contact. Segregation in large, airy rooms; especial care is to be taken in preventing individuals with an inherited tubercular proclivity from coming in contact with a patient already suffering from tuberculosis. Houses or apartments which have been occupied by tubercular patients should be disinfected, clothing and ornaments included.*

The laity are not, unfortunately, as well aware of the fact, as are the members of the medical profession, that there is ten times more evidence of the contagiousness of tuberculosis, in our climate, than there is of leprosy. The incubation period is unknown, if such a period exists.

Typhoid Fever. Careful and thorough search for the origin of the infection; water supply, sewerage, drainage, ventilation, etc., to be gone over carefully. Thorough and effective disinfection of all excreta, clothing, bedding, etc., which has come in contact with the patient and as thorough isolation as may be practicable in private families. So far as now known, no one has advised careful isolation. The period of incubation in this very common disease has long been a matter of considerable debate. From reliable data it would appear that its development occurs within two weeks following the exposure, although some are of the

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* Earrings, the property of a tuberculous patient, have been known to communicate the disease when worn by one susceptible to the disease.

opinion that it may develop as early as the sixth and as late as the twenty-fourth day.

Typhus Fever. The most thorough and efficient isolation necessary; depopulation of the infected district, abundance of fresh air, outdoor tenting; if in the house, abundant ventilation in large, airy rooms. Flint says: "A single patient in a spacious, well-ventilated room will rarely communicate the disease." Thorough disinfection of clothing, habitation, etc. Extreme cleanliness, and perfect sanitation in infected areas. Contagiousness exists until late into convalescence, and hence great care should be manifested lest the disease be communicated by too early removal. The period of incubation is most extraordinary in range, the disease usually appearing from the seventh to the twelfth day; however, in rare cases, it does not manifest itself before the twenty-first day and even slightly later; at other times the symptoms come on within from twenty-four to forty-eight hours after exposure.

Smallpox, or Variola. The prevention of this disease is largely based upon the success of vaccination, a matter into which it is not necessary for us to go. When the disease breaks out, most thorough isolation must be established, all communication with the infected house should be prohibited, disinfection of everything absolutely necessary. Isolation should be in large, airy rooms, and the patient should not be allowed to associate with the healthy until after all crusts have disappeared and repeated baths have removed all evidence of the eruption except, of course, the scars. No clothing, either personal or bed clothing, should be allowed to leave the infected area; it should all be burned; house, bedsteads, and furniture of every kind disinfected; window hangings, carpets, etc., treated exactly as clothing. Smallpox usually manifests itself in twelve days. It may, however, appear much earlier, and in rare cases may not develop until the twentieth day.

Modified Smallpox, or Varioloid, is as communicable as true smallpox and demands the same care. The incubation period is about the same as true smallpox. The danger of mistaking varicella during an epidemic is so great that it had best be treated as varioloid; in suspicious cases never the reverse.

Whooping Cough. The disease may be communicated after an isolation of several weeks. Period of incubation varies, but is most commonly about ten days, varying from six to fifteen days.

Yellow Fever. The contagiousness of this disease is not as yet proven, indeed, it is debatable if it be directly contagious. The prevention of its spread will depend largely upon isolation of individuals, disinfection of all materials coming away from the sick, depopulation of the infected district, careful attention given to the water and food supply, including milk. Although cold will destroy the disease, as is proven by frost, still, the applicability of cold on a large scale has not yet been demonstrated. One of the essential features is to prevent unacclimatized individuals from entering the yellow fever area during an epidemic. Repeated ablutions and sterilization of clothing to terminate the isolation, which should be prolonged. The period of incubation varies from twenty-four hours to seven days. As a rule, it manifests itself from the first to third day.

Oriental Plague. For the prevention of Oriental plague, or bubonic plague, and that unique disease known as the "sweating sickness," there seems nothing which is so important as raising the general sanitary condition to the highest possible standard. This seems to determine the subsidence of the epidemic. Where this cannot be carried out readily, it is probably better to depopulate the infected area entirely. Isolation should be maintained, and as nothing is known of the etiology of these diseases, they should be treated as though due to a microörganism possessing unusual resistance.

Vaccination or Inoculation.

The prevention of disease, more especially the infectious and contagious diseases, by means of inoculation, is rapidly assuming importance. The suppression of smallpox by means of vaccination led observers, more particularly Pasteur, in France, to investigate similar processes in the prevention of other diseases. This he tried first in chicken septicemia with apparent success; later the same principle was applied to rabies, and, since this well-known experiment, attempts have been made to establish the process successfully in the treatment of various infectious diseases. The facts are as yet too recent for us to draw any definite conclusions; it is, however, probable that certain diseases, more particularly those having a tendency to run a definite course and to be self limited, will afford equal opportunity for the introduction of this method of preventive medicine, as is well proven and now universally adopted in smallpox.

Induced immunity varies in degree and may be brought about in more than one way. For example: the microörganism causing the disease may be cultivated under unsuitable conditions, diminishing its viability and the activity of its pathogenesis. The animal to be rendered immune may then be inoculated with this culture. There may or may not be a light form of the disease following; if there is not, the animal will again be inoculated by a more virulent culture, and thus through progressive series of more and more virulent cultures, and finally exposure to the immediate contagion of the disease in question. The immunity so induced varies in its duration. This is not considered as efficient and long acting as the immunity acquired by the actual inception and progressive development of the disease itself. Another method of inducing immunity is by introducing gradually into the system the chemical products of the organism which causes the disease, and imparting to the system a condition of tissue which resists invasion by the organism itself. Again, the process has been modified by introducing into the economy of the animal, by the hypodermic method, blood serum from an animal possessing immunity, either hereditary, acquired or induced. These methods not only promise well, as to the induction of immunity, but are also applicable in the treatment of the disease. If the experiments on animals afford a criterion, we have much to hope from acquired immunity; as to man, we have too little evidence at present from which to draw any conclusive inferences. Tetanus has been successfully treated by the serum of immunized animals.

Disinfectants, Deodorants, Means for Securing Disinfection, Agents to be Used.

Disinfection means a destruction of infective material, and agents used for securing disinfection are known as *disinfectants*. Recently, through modern surgical nomenclature antiseptics have been confused with disinfectants. *Antiseptics* should properly include those agents which retard the growth of germs without destroying them. *Disinfectants*, on the other hand, are true germicides, or germ destroyers. A weak solution of a disinfectant or a germicide is, in nearly all cases, an antiseptic; the reverse, however, is by no means true. Thus cold is an antiseptic, but it cannot be reduced to a sufficiently low degree to be depended upon for germicidal purposes. *Disinfectants* or *germicides* may be divided into *physiological*, *chemical*, and *thermal.*

Physiological germicides. Among the physiological disinfectants or germicides we are to include some of the secretions and excretions of the body, blood, and serum, and some of the cellular elements which constitute a part of the animal organism. Thus it has been shown that certain juices of the body are destructive to some infective agents, the cholera bacillus being destroyed by a normal gastric juice. The theory of phagocytosis is based upon the apparent destruction of bacteria by the white blood corpuscles, thus placing them among the physiological germicides. That this theory may or may not be tenable it is not our function to debate; however, it has so far fairly well combated the antagonism which threatened to engulf it. Upon the activity of the physiological germicides depends that condition which we have designated as inherited or hereditary immunity,and possibly, other forms of immunity as well.

The *chemical germicides* which have been brought forward at different times are innumerable. Practical experience, cost, and efficiency have, however, restricted these, by the slow process of exclusion, to a very few that may now be depended upon. Unfortunately, none of these are applicable under all conditions, and are to be used differently, depending upon the material to be disinfected and other considerations which we will discuss separately.

Among the solids we have chlorid of lime, corrosive sublimate, sulphate of iron, sulphate of copper, chlorid of zinc, and chlorinated soda. These may be used either in a powder or in a solution—the chlorid of lime commonly used in powder; the sulphates of iron and copper and the chlorid of zinc may be applied in the powder form; the best results will be attained by using them in solution. The chlorid of lime and the chlorinated lime differ but very little; it will be ordinarily found that, as purchased from the shops, the two are practically identical. Chlorinated lime is used, as a rule, in a solution of not less than four per cent., and should contain fully twenty-five per cent. of available chlorin. Corrosive sublimate should be used in an aqueous solution, not weaker than one to five hundred, and preferably of a strength of one to one hundred where very great resistance is anticipated, as in destruction of the bacillus of anthrax or its spores. The great objection to the corrosive sublimate lies in the fact that when brought in contact with albumin it is precipitated as the albuminate of mercury, which has no germicidal action worthy of consideration. Recent experiments have seemed to prove that a combination of tartaric acid with corrosive sublimate lessens the probability of its decomposition. This, however, for sanitary disinfection, is scarcely feasible. In the writers' laboratory Mr. Spencer, now Dr. Spencer, demonstrated that a solution of peroxid of hydroden (15 volumes), combined with a solution of corrosive sublimate (any strength), in a proportion of one part of hydrogen peroxid solution to three parts of the corrosive sublimate solution, prevented the corrosive sublimate from being precipitated when coming in contact with albumin; if this experiment be verified by further experimentation, the combination will be very useful in sanitary disinfection. The objections to chlorinated lime are urgent; it is an extremely active bleaching agent, more or less rapidly destroying all materials with which it may come in contact, and, taken all in all, is of doubtful efficiency unless used in concentrated solutions. One great objection to all disinfectants possessing an active or repugnant odor lies in the fact that the laity are liable to fear their use in a sufficiently concentrated form, and commercial cupidity extremely likely to humbug the public, including, we are sorry to say, a part of the medical profession, by loud-smelling agents of worse than questionable virtues. The lime preparations depend upon the chlorin which they contain for a great amount of their usefulness. As ordinarily purchased in the shops they are not assayed, and the containers, being pervious, permit of such abundant escape of the chlorin, that no constant percentage of the active disinfecting agent can be depended upon. Sulphate of iron is a fairly efficient disinfectant, if we may believe the experiments which have been made by several observers. Its efficiency is a matter of sufficient doubt to render its use not advisable. Sulphate of copper and chlorid of zinc are efficient if used in strong solutions, the copper in not less than ten per cent. solutions and the chlorid of zinc slightly stronger, say from twelve to sixteen per cent. It is unnecessary to say that all of these solutions are too strong for disinfecting the hands.

Carbolic acid has been highly recommended as a disinfectant. It should be used in very strong solutions, and the making of these solutions is an important matter, as upon that depends the efficiency of the germicide. A five per cent. solution of the carbolic acid is usually prepared by adding the acid to sufficient water and mixing. A solution so made is almost useless, and if carefully examined the acid will be found suspended in small drops throughout the mixture; it is not a solution. In order to prepare carbolic acid solutions, the acid should be thoroughly mixed with an equal quantity of glycerin before it is added to the water; if the glycerin and acid be thoroughly mixed, very little difficulty will be found in securing a solution in the water. The writers are inclined to think that the weak solutions of carbolic acid, meaning, thereby, solutions of five per cent. or less in strength, are of questionable value, and should never be used where a disinfectant is desired which may be depended upon. When typhoid fever bacilli can be cultivated in a one-half per cent. solution of carbolic acid, one is to doubt the efficiency of a five per cent. solution as a germicide; we cannot for a moment believe that solutions weaker than ten per cent. are to be depended upon. Ten per cent. cannot be made in water except by the use of glycerin.

Among the gases or vapors which may be used as disinfectants, we have *chlorin*, *bromin*, and *iodin* as the most active, while that most commonly used is *sulphurous acid gas*.

Bromin is probably the most efficient and thorough disinfectant which we possess in the gaseous form; its germicidal powers are something tremendous, and its penetration fairly good. The matter of penetration is something not usually taken into consideration when dealing with the disinfection of large quantities of materials. It is, however, vastly important. Observations made in the writers' laboratory by Kyle, Spencer, and others have proved, beyond a doubt, that bromin is twenty times as efficient, in a small space, not exceeding possibly eight cubic feet, as sulphurous acid gas.

The objections to bromin are the extremely irritating character of the gas and the fact that its high specific gravity renders its diffusion unsatisfactory. In a small space, reasonably tight, there is no agent whose efficiency is more to be depended upon than bromin. One ounce of bromin should be used for each twenty cubic feet of space to be disinfected. This is efficient but expensive.

Iodin may be vaporized in a room by means of heat applied to a saucer or stove-lid upon which the iodin has been placed. The objections to iodin are the same as bromin; furthermore it is likely to crystallize at ordinary temperatures, and thus lose its efficiency, making it less available than either bromin or chlorin, and weak in diffusion and penetration.

Chlorin. This gas is undoubtedly the most efficient disinfecting agent that we possess, with the probable exception of bromin. Where it can be applied in sufficient volume it is not only a thoroughly efficient disinfectant, but an excellent deodorant as well. As already stated, it is the active principle in the chlorid of lime and chlorinated soda. The British Army Medical Regulations advise that for every one thousand cubic feet of space to be disinfected, the following should be used: Common salt, 8 oz.; manganese dioxid, 2 oz.; sulphuric acid, 2 oz.; water, 3 oz.; the salt and dioxid of manganese should be mixed in an earthen vessel and placed upon a bed of sand, the sulphuric acid and water should be mixed and allowed to cool, after which the mixture is poured over the other ingredients in the basin. The efficiency of chlorin as a disinfectant is enhanced by the presence of moisture in the room; this may be accomplished by suspending in the room moistened sheets; or Parkes recommends that the walls and floors be moistened, a procedure which would insure their being thoroughly bleached. The objection to chlorin is its highly irritating character and the fact that it bleaches organic pigments, thus destroying the wall paper, window hangings, etc.; the latter could be removed from rooms and disinfected by other means if they be of sufficient value to demand protection from injury. Chlorin is twenty times more diffusible than bromin, and is, for this reason, to be considered more efficient.

Sulphurous acid, or, more properly, sulphur dioxid, is most easily evolved by burning sulphur in the presence of oxygen. Not less than four pounds of sulphur should be burned for each thousand cubic feet to be disinfected. As is the case with other gases, it seems to act far more efficiently where moisture is present, and hence every effort should be made to secure an abundance of aqueous vapor in the atmosphere. Where sulphurous acid is used on a large scale, this is secured by forcing in a jet of steam, and in houses where steam radiators are to be had these can be relied upon to supply moisture, otherwise, it may be accomplished as described for chlorin. Sulphurous acid is bleaching to a small degree, very much less so than chlorin, and is not nearly so efficient as the other gases already enumerated for disinfecting purposes; indeed, it is debatable whether the gas can be regarded as sufficiently active to demand the confidence which is now placed in it.

Fig. 27.

Simple Contrivance for Generating Sulphurous Acid Gas.

A. Shallow iron pan. B. Bricks upon which the pan rests. C. Hot bricks from which steam is rising. The larger vessel may be either a washing-tub or boiler, or a large bucket.

Carbolic acid vapor. The vapor of carbolic acid has been supposed to possess some disinfecting properties; however, as ordinarily applied, by sprinkling walls, floors, etc., its efficiency is a matter of great doubt. The amount which the air takes up differs enormously at different times and is dependent largely upon conditions so poorly understood that but little confidence can be placed in it. It more thoroughly than any other gaseous substance of which we have spoken disguises, but does not destroy, whatever odor may be present in the air, and for this reason alone is objectionable.

Nitrous acid or nitrogen tetroxid has been proposed—indeed, used—by some as a disinfectant for the air. For every thousand feet of air to be disinfected, the following should be used: Copper shavings, 1½ ozs.; nitric acid, 4 ozs.; water, 4½ ozs. The efficiency of this gas is still a matter of some doubt.

Thermal Disinfectants. All disease germs have what is known as an optimum temperature, a temperature at which they grow best. Any temperature above or below this point tends to diminish the activity of their growth, and, under certain circumstances, to kill them.

Cold, with the exception of one disease, seems to be utterly inefficient as a disinfectant. Bacteria have been reduced to temperatures many degrees below zero, and when brought back to a suitable temperature their growth went on uninterruptedly. It would, however, appear that in yellow fever cold exercises a most beneficent influence; as is well known, autumnal frost arrests the progress of the disease wherever it may manifest itself.

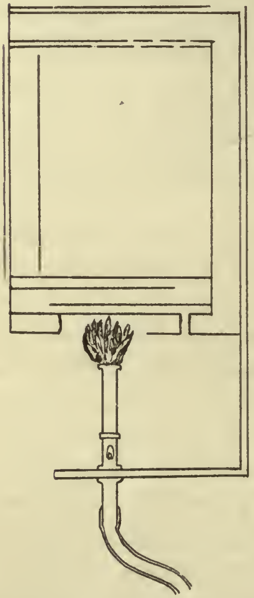
Heat is the most efficient germicide or disinfectant that we possess. While a long list of temperatures might be given presumably efficient in certain instances, it is better, safer, and wiser to resort only to that temperature which, under all circumstances, can be depended upon. (For thermal death-point, see Appendix.)

Heat may be applied in either of three ways: First, *moist heat;* second, *dry heat;* third, *heat under high tension or pressure*, either moist or dry.

Dry heat is rarely applicable on a large scale, and in order to be efficient demands a comparatively high temperature; thus, to destroy the bacillus of anthrax in the spore form a temperature of not less than 250° F. is demanded. It will be readily seen that this temperature almost invariably destroys any material which may be subjected to it.

The high temperature demanded for disinfection by dry heat, its probable destruction of the material to be disinfected, and its impracticability, have rendered its use almost obsolete. When such enormous temperatures are demanded as indicated above, where the loss will not be too great, the material should be burned. In quarantine service it

FIG. 28.



SECTIONAL VIEW OF A DRY AIR STERILIZER, showing jacket for hot air, which is heated before the interior. No matter upon what scale a hot-air sterilizer may be constructed, the superheated jacket is a necessity.

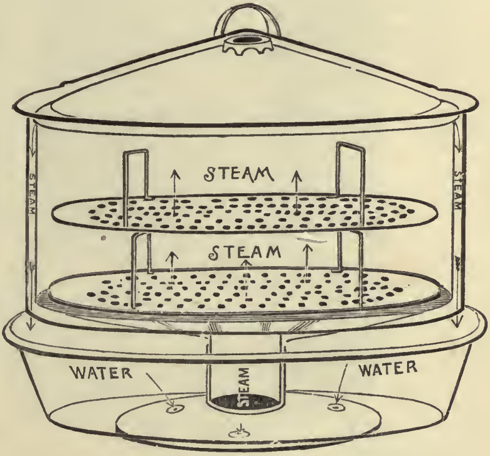
is very constantly found that those things most likely to be infected are sufficiently cheap and inexpensive to render their loss a matter worthy of no consideration. Where dry heat is to be used, some of the forms of sterilizers by hot air must be resorted to; of these there are a large number on the market. The accompanying diagram illustrates the essential elements necessary in a hot-air sterilizer.

Moist Heat. Moist heat may be applied either as steam or boiling water; the steam is preferable, as it secures better penetration and is not so likely to injure the goods as boiling. Many forms of steam sterilizers have been proposed from time to time for various purposes. It is essential, in disinfecting by steam, that we have three things: First, the oven, which must be incased in some non-conducting material to prevent the rapid radiation of heat and cooling of the surface, which causes condensation of the steam in the interior; second, an abundant supply of steam, which should, if possible, be delivered super-

FIG. 29.

FIRST FORM OF ARNOLD'S STEAM STERILIZER.
Tall, narrow, disinfecting chamber.

FIG. 30.

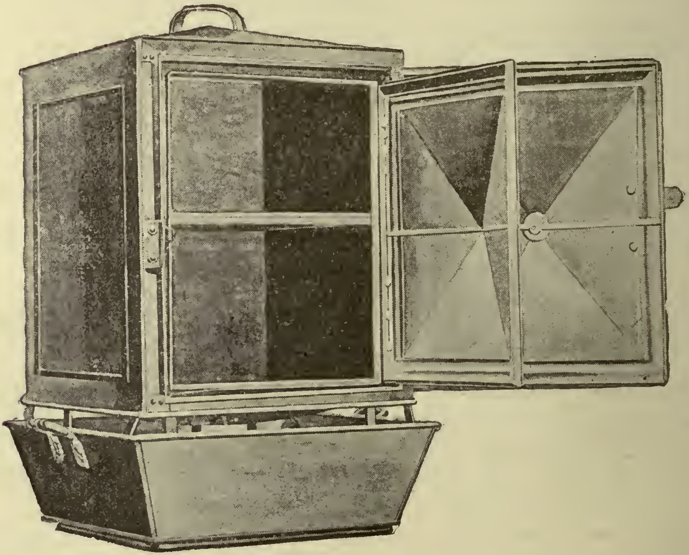


SECOND FORM OF ARNOLD'S STEAM STERILIZER.
Low disinfecting chamber, with greatly increased diameter.

heated; third, an outlet by which the steam can be allowed to escape and fresh steam admitted from time to time. It is desirous that the supply should be constant, and this demands that the exit shall be equally continuous.

Heat under high tension or pressure. In laboratory investigations it has been found that either hot air or steam under a pressure of two or three atmospheres has more than treble the disinfecting power of the same degree of heat as ordinarily applied. The essential features in order to disinfect by heat are penetration as well as elevation of temperature; this the increased pressure greatly facilitates and aids materially in securing a necessary degree of heat in the interior of materials subjected to its action. The apparatus ordinarily employed in the laboratories and in Europe for disinfecting purposes under pressure is known as a "digester."

FIG. 31.



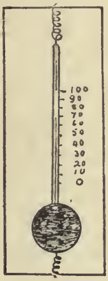
THIRD FORM OF ARNOLD'S STEAM STERILIZER. (Form used by Boston Health Board.) Constructed on same general plan as those shown in Figs. 29 and 30.

Not only may heat be used in the forms already referred to, but the steam or hot air may be made a carrier of other disinfecting agents: thus, in the application of steam, the water from which the steam is to be generated may be highly charged with carbolic acid, or carbolic acid may be allowed to mix with the steam in the sterilizer. In the former case if the steam be heavily charged with carbolic acid and the charge continued until the sterilization is half completed, and if the succeeding steam admitted be free from the acid, nearly all the odor in the disinfecting chamber will be driven out by the uncharged steam.

In selecting or having constructed an apparatus for sterilizing by heat, the most important factor is to see that all parts of the disinfecting chamber can be raised to the same temperature. This, of course, is to be largely facilitated, where the disinfecting chamber is one of great size, by a thorough insulation of its surface and by the delivery of the heat at two or more orifices, and exits being allowed through several openings so arranged that they can be opened successively, thus preventing the formation of a current in any one direction to the exclusion of other parts of the chamber, at the same time directing the heat flow in different channels.

Where dry heat is applied at a temperature of not less than 220° F., it should be used continuously for one hour; if a higher temperature is used a shorter time will suffice. Moist heat should be applied for not less than an hour at a temperature of 212° F., and preferably for a longer time. In the "digester," when the temperature reaches 215° F. and the pressure is two atmospheres, a shorter time will be sufficient. With regard to the element of time, it is a matter of great importance to date the length of exposure from the time when the temperature reaches the desired degree; this is best determined in large disinfecting ovens by means of electric contact thermometers placed at different localities throughout the mass to be disinfected. These can be set to indicate when any given degree is reached, and the time at which the sterilization should be presumed to begin is when all these thermometers indicate the same degree, say 212° F. or 215° F., or whatever temperature it may be desirable to use. The foregoing specifications as to time are

FIG. 32.



CONTACT THERMOMETER, with fixed point of contact; in this instrument the degrees are marked as in the ordinary thermometer. In contact thermometers which can be "set," the upper platinum wire can be raised or lowered by means of a set screw or clamp.

presumed to be applied under the rule just given. These electric contact thermometers are now on the market, or may be constructed by any glass-blower from the accompanying diagram. (See *Thermostat*, in article on heating.)

Heat may be applied interruptedly, and this undoubtedly affords a most admirable method for disinfection. Where prolonged or continuous heat will destroy the material, it may be heated for twenty minutes to a half hour each day for four successive days, by means of which disinfection will be accomplished.

Deodorants. Some of the disinfectants which have been mentioned are actively deodorant, for example, chlorin, bromin, sulphurous acid, and possibly carbolic acid.

It is to be remembered that there is a great difference between deodorizing and disinfecting, and that for all practical purposes the two should be considered separately. If, for example, it be desirable to disinfect a room, the most thorough applicable disinfectants should be used and allowed to act until all reasonable doubt has been removed; they are then to be followed by deodorants if they themselves have not so acted.

Chlorin or bromin will be found a most efficient deodorant. The chlorin may be used in the shape of chlorinated lime sprinkled about where the odor arises, preferably at its source. Permanganate of potassium is a most efficient deodorant, although its efficiency as a disinfecting agent is doubtful. In order to apply permanganate of potassium as a deodorant, it may be used where fluid is present, as in cesspools and water-closets, by sprinkling the powder over the moistened material from which the odor is emanating, or if a sufficient degree of moisture is not present, a solution of the salt may be applied, the strength varying but little from that of a saturated solution.

Special Disinfection.

The Disinfection of a Patient after Recovery from or Exposure to a Contagious Disease. The body should be washed from head to foot thoroughly, with a good alkaline soap, in order to remove any grease which may be present, and then, after rinsing the soap off, the body should be bathed in a solution of corrosive sublimate, made by taking three hundred parts of hydrogen peroxid (15 vol. solution), seven hundred parts of water, and one part of corrosive sublimate. The removal of the grease may be secured by using alcohol (bathing alcohol), or whisky, or soap liniment It is highly probable that the soap, under ordinary circumstances, is the best agent which we possess, as people will use it more freely and more thoroughly than any of the ordinary preparations. The greatest care should be given to the hairy parts of the body, including the head, axilla, and genital region. Carbolic acid solutions are not to be trusted. After the application of the corrosive sublimate solution of the strength of one to one thousand, a one to four or five thousand solution should be applied, and this be allowed to dry on the skin. The patient is now to be dressed in an entire change of clothes. The process may be repeated on the following day, after which it is to be presumed that the danger of spreading the disease is over. It is well to remember that where a healthy individual has been isolated, he should be treated after the termination of the period of isolation exactly as though he had just passed through the disease. If he has been exposed to the contagion he may have escaped by reason of individual immunity, but if allowed to go free he may carry the disease with him just as much as if he had gone directly from the source of the contagion to the public at large.

For *disinfecting the hands* the following methods are to be recommended :—

The nails should be short and clean.

The hands are thoroughly washed for several minutes with soap and water, the water being as warm as can be comfortably borne, and being changed frequently. Use a brush which has been sterilized by steam. The excess of soap is washed off with clean, warm water. The hands are immersed for one or two minutes in a warm saturated solution of permanganate of potash, and are rubbed over thoroughly with a sterilized swab. Then place the hands in a warm saturated solution of oxalic acid until they are completely decolorized. Wash the hands with a sterilized normal salt solution (.5 per cent.). Immerse the hands for two minutes in a one to five-hundred solution of the bichlorid of mercury and wash in boiled distilled water.

Prof. Keen, at the Jefferson Medical College Hospital, uses the following method :—

The hands are washed with soap and warm water, the nails, being cleaned and trimmed with a knife, are then scoured with a sterilized brush. All loose skin about the nails is removed. The hands are again washed in warm water, but without soap. Immerse the hands in alcohol for two minutes and briskly rub one over the other. They are then immersed in a one to one thousand solution of the bichlorid of mercury. This method is a most excellent one. The writers have tested the skin and nails after being sterilized as above directed, and also cat-gut and silk, which were handled by the operator or his assistants, with almost invariably negative results. In obstetrical and gynecological work creolin and lysol have been largely used. Their efficiency is questionable, although some experimenters have been led to believe that in solutions varying from one to five per cent. they are disinfectants; they probably are merely antiseptics of not a very high order.

For the *disinfection* of *surgical instruments* heat is by far the most desirable. As a rule it is applied moist, either by boiling the instruments or by steaming them in suitable receptacles. The Arnold and Schimmelbausch sterilizers are most extensively used for moist heat; the former uses steam, the latter contains a reservoir in which the instruments are placed and boiled. Rusting is prevented by using a one per cent. aqueous solution of carbonate of sodium. Non-metallic instruments may be disinfected in corrosive sublimate solution, and carbolic acid solution may be used upon metallic instruments. Where heat is not available, disinfection may be accomplished by immersing the instrument for half an hour in a ten per cent. solution of carbolic acid, made with glycerin, as already directed. At the end of the half hour, the carbolic acid is poured off and boiling water poured over the instruments, which, upon cooling, may be poured off, or the instruments may be allowed to remain in it and used from the tray containing the boiling water.

Disinfection of Clothing. Where the clothing is not too expensive it should be burned, as it is questionable whether we can insure disinfection under ordinary circumstances. Where heat can be applied for a sufficient length of time and to a high degree, we may be reasonably sure of the disinfection of the material exposed. In clothing, however, this is not readily attainable. Bed clothing, window hangings, carpets, etc., should be treated exactly as clothing, and where they can be subjected to heat, in any of its forms, that method of disinfection should be resorted to. Where heat cannot be applied, materials should be immersed in a solution of corrosive sublimate not weaker than one part of the drug to eight hundred parts of water. Carbolic acid for the disinfection of clothing is not to be recommended if corrosive sublimate can be used. Where the carbolic acid is applied, it should be in a ten per cent. solution, and the exposure should be for several hours. If the corrosive sublimate acts for one hour, the disinfection may be assumed to be complete, and the material may be washed in water. Materials which have received the discharges of the sick or have become soiled should be destroyed by burning or subjected to a temperature of not less than 212° F. for one hour, if moist heat, or 230° to 240° F. for not less than one and one-half, preferably two hours, if dry heat be used.

Walls, floors, bedsteads, and furniture, other than upholstered furniture, which can never be disinfected without injury, should be washed with soap and water, and then with a solution of corrosive sublimate, one to eight hundred, followed by rinsing the corrosive sublimate off with water. Carbolic acid solutions are not to be strongly recommended, although if a ten per cent. solution be used it may be considered as fairly reliable. Disinfection of rooms by fumigation with sulphur dioxid for twelve to twenty-four hours may be resorted to. The room should be rendered as nearly air-tight as possible by pasting paper on the *outside* of all cracks, key-holes, etc., and by packing it under the doors and window crevices before the sulphur is burned.

Hospitals, *ships*, *railway cars*, *ambulances*, and *carriages* used for the transportation of the sick, can all be disinfected by some of the methods given above. Spraying the atmosphere in rooms, hospitals, etc., is an utterly valueless and misleading procedure.

For the *disinfection of the mails*, sulphur dioxid or, possibly, chlorin or bromin may be used; bleaching and other injurious effects will probably follow the use of the latter two. Dry heat may be used to advantage.

The *disinfection of excreta* may be accomplished by the use of strong solutions of corrosive sublimate, not weaker than one to one thousand, pure carbolic acid and glycerin, equal parts, by incineration in a suitable furnace, by chlorin or chlorin water, and, where nothing else is to be had, chlorinated lime may be used. If a disinfecting solution be used, the quantity should always exceed the amount of excreta to be disinfected, and allowance should be made for the dilution.

The *disinfection of the sick* during the progress of the disease is not at all feasible, and concentration of the poison in the room is to be avoided by free ventilation. If the air leaving the room is conducted into a heater flue, as is arranged in some hospitals, or filtered through cotton at the point of exit, no fear need be anticipated from this source for those occupying adjoining space.

Occasionally it may be desirable to disinfect water, milk, and other foods prior to their ingestion, in which cases the readers are referred to the chapter upon these subjects, at the same time remembering that heat is the only available and reliable disinfectant which we possess that is applicable under these circumstances.

The Handling of the Dead from Contagious Diseases. As a rule the body should be allowed to remain in the room until all the preparations have been made for the funeral. It should be "laid out" on a marble-top stand or table, if one be in the room, if not, upon a board, which is either used exclusively for that purpose, or, preferably, which can afterwards be destroyed. The body should be wrapped in cotton or linen, or a sheet, if neither of the others can be obtained, saturated with a strong solution of bichlorid of mercury, not weaker than one to five hundred, and it is preferable that it contain ten per cent. of glycerin, as this will prevent the wrapping material from becoming dry and the antiseptic losing its efficiency. If for any reason corrosive sublimate is not to be had, carbolic acid may be used, although the writers place very little confidence in the germicidal action of the solutions of carbolic acid which are usually employed. A strength of not less than ten per cent. is of very doubtful efficiency, and a stronger solution, indeed, a solution of that strength, will be destructive to the hands of those applying it. If absorbent cotton be used for the wrapping of the body it may be applied and then saturated with the antiseptic. No part of the body should be left exposed, and the habit of leaving the face uncovered is to be highly condemned. Under all circumstances the body should be placed in an air-tight casket and sealed at the earliest possible moment. Just before sealing the casket it has been found advantageous to start the generation of chlorin gas by putting in the casket a small box which contains chlorinated lime upon which two or three teaspoonfuls of diluted sulphuric acid have been poured. Where a contagious disease is raging in an epidemic form, caskets for burial should be in constant readiness, and the laying out of those dead from the disease should be prohibited. As after burial it has been shown that disease may be propagated possibly from infected graveyards, the filling of the casket, partly at least, with quicklime, is, wherever applicable, always to be strongly urged. Cremation, of course, affords the most efficient method of disposing of those dead of any contagious disease, as it thereby entirely removes the danger arising from graveyards, vaults, etc. Unfortunately, the laity, indeed, we might say the medical profession, has not reached that point of scientific education where they are ready to accept incineration. Under all circumstances the body should be disposed of, either by burial or preferably cremation, at the earliest possible moment. Public funerals are to be discouraged, private interment is to be ordered, and in epidemics the undertakers who are employed in the burial of contagious cases should be prohibited from entering uninfected houses, or from employing any of the materials or appliances which have been used in the infected house for or during the interment of those dying from some benign disease. It seems highly advisable to the writers that, during the raging of an epidemic, all funerals of whatever class or kind, should be without public demonstration, as this lessens the likelihood of undiagnosticated cases giving rise to infection, and diminishes the tendency to aggregation of individuals, which must, inevitably, sooner or later, afford ample opportunity for wide-spread infection.

CHAPTER II.

INDIVIDUAL OR PERSONAL HYGIENE.

Individual or personal hygiene may be divided, according to age, into arbitrary periods, or subdivisions, based on certain ill-defined changes presumed to occur at or during given years. First, *the infant*, from birth until the fourth or fifth year; second, *the child*, from the fourth or fifth year to the twelfth year; third, the *young adult*, from the twelfth to the eighteenth year; fourth, *the adult*, from the eighteenth year to the termination of life. If the individual lives long enough, there develops that age at which the general faculties begin to wear out, the muscular and fibrous tissues of the body to waste, and general physical decay manifest itself. This condition is known as *old age*.

The Infant. At birth, careful examination should be made to be sure that no malformations or maldevelopments are present. The treatment of the umbilical cord is a matter for the obstetrician.

Feeding. The first and most important thing to be considered with regard to the infant is its diet. No food, either derived from the lower animals or the product of synthesis, can approach mother's milk. The child should be put to the breast as soon after birth as the mother's condition will permit, and should be nursed at regular intervals of two or three hours for the first three or four months, after which the interval between the feedings may be lengthened. In case the mother's milk threatens to fail, her diet must be such as to favor the production of milk, and, at the same time, her labor should be reduced to a minimum, to prevent the excessive burning of food for the production of heat and force. She should take a limited amount of exercise; plenty of rest. Her food should be administered often, and should be, as already stated, of a highly nutritious nature. Here porter, beer, and other malt preparations seem to be admirably adapted. In case the mother cannot supply food for the child, the question naturally arises:

What shall we give it? Dr. Coplin, having been for several years associated with an institution for the care of children, the Philadelphia Sanitarium, can speak with some confidence upon the matter of infant feeding. Having experimented with nearly all forms of artificial food, he is ready to announce a decided preference for sterilized milk in some of its forms. Pasteurized milk, that is milk sterilized by intermittent heating, at comparatively low temperatures, 140° F. to 160° F., is now largely used. The milk should have added to it a small percentage of cream and some lime-water, with milk sugar, following the formula advised by Dr. E. P. Davis; the most important feature, the essential element, is the sterilization. We are persuaded that one reason why sterilized milk does not always agree with infants is that bacterial products develop within the milk prior to its sterilization. At the Sanitarium, the milk was brought immediately from the dairy, and twenty minutes after it left the cow was in the sterilizer. Apparatus for the sterilization of milk has become so cheap and so readily obtainable that there is no excuse for the administration of any other form of diet until after sterilized milk has been tried. There may be circumstances under which the administration of sterilized milk would be accomplished only through great difficulty; in such instances it will be found advisable to try some of the artificial foods that are upon the market. It is well for the physician to remember that ninety-nine times in the hundred it is a practical impossibility to prescribe an irrevocable diet for man in health, and for a medical man to claim that one diet under all circumstances is to be resorted to, to any thinking man must show evidence of superficiality. The various foods should be tried, one after the other, patiently, conscientiously, carefully, until that one is found which best agrees with the individual case.

For the administration of artificial foods, a plain nursing bottle with nipple should be used. No name, graduation, or other device is to be blown in the bottle, as these but afford crevices for the lodgment of dirt or milk to decompose. The bottle should be cylindrical with a round bottom to facilitate cleaning, and all complicated nursing tubes, nipples, etc., are to be strictly prohibited.

Clothing. The essential elements in clothing the baby are lightness of weight, warmth, and being so made that no tight bands or constricting gathers shall be found around the arms, neck, or waist. Woolen underclothing affords undoubtedly the best protection for infants. The soft and delicate flannels that are so cheap now-a-days can be used for the clothing next to the skin, and, if necessary, a heavier substitute can be put over the light flannel. At night the infant should sleep in a flannel night robe made sufficiently long to be tied below the feet, putting the child in a bag, as it were. The skirts to babies' dresses should always be sufficiently long to cover the feet well, but never long enough to make it a drag on the waist or shoulders. The popular idea of having the child's skirts a yard or a yard and a half long during the first few months after birth is disgusting in the extreme, and should be discouraged in every possible way. Equally reprehensible is the other extreme, short skirts, and the fashionable delusion of short stockings, or socks, as they are called, and little fancy slippers; bare legs exposed alike to cold and moisture favor the development of croup, diphtheria, and intestinal complaints which carry off such multitudes of children every summer. At one time the writers were inclined to think summer a dangerous season for children; they are now of the opinion that it should be the harvest of their growth; that their development should be more rapid, their strength should increase with greatest strides during the summer months, and that which has given the summer a bad name is the reprehensible carelessness and ignorance of those who have the children, more particularly infants, to care for.

Weaning. The question which will often be asked is, when shall I wean the child? This will depend entirely upon the condition of the baby or mother. Where the mother ~~be~~ vigorous, is with abundance of milk, there is no reason why the child should be weaned until after it has passed the second summer; if, however, the evidences are that the milk is not giving sufficient nourishment, and that the child has stopped growing or shows evidence of faulty nutrition, a change of diet is demanded, and other foods than that of the mother must be tried. Here again some of the artificial foods may be used or the child may be put immediately upon a mixed diet composed largely of soups, broths, milk in some of its forms, occasionally some potatoes, but no fruit. Weaning during pregnancy is to be encouraged, although the reason for believing that the milk of the pregnant woman injures the child is not entirely apparent. A proper time should be selected for weaning, and the child should be slowly if possible, abruptly if necessary, transferred from the diet of mother's milk to artificial food.

Air. The baby should have all the out-door life that it is possible to give it, and during pleasant days, summer afternoons and mornings, it should be given an outing in the country or on board an excursion boat; on account of the ease by which country air may be applied, the child should advisably be taken to the country.

Bathing. During the first two years of life the infant should have at least two baths a day. These should be in tepid water in a warm room and given every morning on rising and every night on going to bed: if, during the day, the clothes become soiled as well as the skin itself, topical baths may be resorted to. The clothes should be changed after each bath; even if not soiled they demand an airing.

Sleep. The baby should sleep all that it wants to, but should be given no narcotics or soothing syrups to secure its rest at night. After the evening bath it should be placed in its night-gown, to which we have already referred. The habit of allowing the child to sleep in the clothes that have been worn during the day, a habit not uncommon among all classes, is to be condemned. Infants and children should, under no circumstances, be permitted to sleep with adults; small cribs or cots, now so cheap, can always be obtained. Equally condemnable is the pernicious habit of several children sleeping in the same bed.

Dentition. The period of dentition in children is supposed to be a fruitful source of disease. The writers are not inclined to place very much confidence in the popular idea that every child must be sick when it cuts its teeth. Under proper environment, with sensible food, clothing, etc., nine children out of ten, if otherwise in good health, will cut their teeth without any gastro-intestinal disorder. Although hardly a part of hygiene, it is perhaps wise to refer to the time at which the teeth may be expected. Between the sixth and eighth months after birth the two lower central incisors will most likely cut through simultaneously; by the tenth month the two upper central incisors, followed shortly by the lateral incisors on either side; between the twelfth and fourteenth months the two upper anterior molars may be expected as well as the two inferior lateral incisors and the two lower anterior molars, usually in the order mentioned. From the sixteenth to the twentieth month the canines appear. From the twentieth month to the end of the third year the four posterior molars may be expected. Usually by the end of the third year the eruption of the milk teeth is completed and no more may be expected to appear until the fifth or sixth year, when the temporary teeth usually begin to show evidences of being superseded by the permanent teeth. The temporary teeth usually fall out exactly in the order of their eruption, and the appearance of the permanent teeth is approximately as follows:—Sixth year, first molars; seventh year, central incisors; eighth year, lateral incisors; tenth year, first bicuspids; eleventh year, second bicuspids; twelfth to thirteenth year, the canine, closely followed by the two molars; while from the seventh to the twenty-first year, rarely later, occasionally earlier, the "wisdom" teeth will appear.

The Child.

Contagious Diseases. The question will often arise during the tender years of life whether it be advisable to allow the child to have the usual contagious diseases of childhood, such as chicken-pox, measles, mumps, etc. While it is never wise to rush into danger, in the case of a good, strong, healthy child there is no reason why an effort should be made to prevent its acquiring any of the mild contagious diseases of childhood. Every care, however, should be exerted under all circumstances to keep the child away from scarlet fever, diphtheria, and, of course, smallpox. No pardonable reason can be adduced for allowing a child to contract either of these dangerous diseases where it can be prevented.

Exercise. As soon as a child has reached the age of, say four, five, or six years, abundant exercise is demanded; when the exuberant animal spirit demands the opportunity for manifesting itself, outdoor exercise is always to be encouraged and every effort made to make it sufficiently diversified in order to effect the development of the general muscles of the body, arms, and legs. Mr. Treves very aptly puts this as "scientific romping," a most happy term. The gymnasium or school where exercise is obtained by routine rarely does any good; it is in the home, with the society of selected children who are mutually agreeable to each other, that mental and muscular exercises may be most easily attained, and which at the same time will effect signal benefit to the growing child.

Children should be encouraged in the use of their lungs as well as their hands and arms; do not tie them up in the house and suppress every outburst of enthusiasm; let them "yell;" give them the opportunity to develop the muscular apparatus of the chest, and let them acquire all possible intonations of the voice, from the Indian war-whoop to the confidential whisper of childhood.

Clothing. The general principles with regard to the clothing during childhood are the same as those suggested for infancy. Two important indications to be attained in children's clothing are warmth and a sufficiently porous texture in the goods to permit of vapor and perspiration from the skin readily diffusing itself as rapidly as formed. "Over clothing" is to be considered as absolutely dangerous, while less clothing than an absolute sufficiency is the safer side upon which to err, if error there must be. Smooth flannels should be worn next to the skin. Tight bands at the waist, wrist, elbows, and knees are to be prohibited. Here, in the name of humanity, and the growing and developing woman that is to be, let the Christian mother, who holds up her hands in horror at the ringed nose and pierced ears of the savage, throw aside the all-deforming corset, the circular garter, and pinched, narrow shoe with its abominable high heel. It is worse than useless to advise out-door exercise for the improvement of the muscles of the leg, and the carriage, both of which are interfered with by high heels; and equally unavailing to advise fresh air when jackets and waist-bands restrict the breathing to the thoracic region. These are important and growing evils, the writers are sorry to say, but they none the less demand a hand-to-hand combat, in which good sense, backed by genuine scientific knowledge and a plain dispensation of facts, will in the intelligent, sooner or later, win the day. Mr. Treves very wisely puts it when he says that the clothing of girls at this age is "an aggregation of hygienic errors." The clothing should be as light in weight as is compatible with the desired degree of warmth. It should be so constructed as to prevent pulling upon the hips or pressure upon the abdomen, and preferably should be suspended from the shoulders. Every possible freedom of motion should be facilitated by the freedom and looseness of the garment.

Diet. The diet of childhood is to be considered as merely a sensible diet. Sweets and candies, preserves, cakes, and pies, are to be eschewed, and a substantial diet, favorable to the growth of bone and the development of muscles, is to be encouraged. The question of the regularity of meals is to be brought up. Mothers often discourage feeding between meals, which is an error; children should be fed whenever they are hungry; what has brought feeding between meals into disrepute is giving them whatever the taste desires, and not the wise administration of suitable diet whenever it may be necessary. If a child wants a drink, let it have a drink; if it is hungry for food instead of water, there is no more reason for withholding it. A fruitful cause of diseases in children is regular feeding; the child gets ravenously hungry, and then overloads its stomach with the very first thing that is offered at the table, thus bankrupting the digestion, dilating the stomach, and leading indirectly to loss of appetite and all the symptoms of dyspepsia, with its concomitants.

School. At what time shall the child go to school? Now, that is a question as easily answered as will be one later: "At what age shall marriage take place?" The same answer will be given: whenever the individual is old enough physically, not in years. Education is to begin early, and the school, instead of being the beginning, should be a continuation. Intelligent parents begin the education of their children at extremely tender years. Train up inquisitiveness in the child; make that inquisitiveness intelligent; combat any impertinent inquisitiveness by good reasons, showing why it is wrong; allow every question to have a logical point before you answer it. During the first six or seven years, the education should be by observation. One might be able to read and comprehend an encyclopedia on astronomy, but neither pictures nor text could ever instruct in the appearance of the moon like one good, interesting evening's talk, with the moon in view; let the parent have nothing about the house which he has not time to explain. The childish picture-books are well enough, but you cannot and should not expect a child under seven or eight, better nine or ten years, to settle down and learn reading with the object of acquiring knowledge; let it see from you how your ability to read assists you; make it anxious to learn to read. In other words, make the acquisition of knowledge a pleasure and not labor. This is no hard task; it is in the large majority of cases easily directed. The tendency of the times to let somebody else teach the children, a governess or a private tutor, may be commendable in those who are too ignorant to teach children, but under no other circumstances. The mother who is too much interested in Christianizing savages, or preventing cruelty to animals, or lifting drunkards, had better set aside some of her enthusiasm in these directions and let the charity begin at home. It is time that religious reformers, as well as sensible people in general, should recognize the fact that there will be barbarians and heathens at home as well as barbarians and heathens in the distant climes, unless they can and will care for the members of their own households.

Before the child is put at reading and study of books and printed matter, it should be ascertained whether its physical condition is such as to bear the confinement of the school-room, which is usually a collection of unscientific seats, benches, and desks, with windows facing the pupils, if the lighting be at all efficient, and the ventilation a little better than a dungeon and not quite so good as a ship's hold. The parent should, if the school teacher does not, see to these things, for no matter how well educated the child may be, if the chest is deformed by an improper attitude, and the health undermined by poor ventilation and crowding, it is not at all likely that any degree of knowledge will greatly benefit the child. The best way to find out whether a child is old enough to go to school is by experiment; send it to the best school in your neighborhood, and if it is able to successfully combat the poor hygienic surroundings of the institution, remains healthy, and does not lose flesh, does not become pale, is not weak and exhausted after its day's labors, the inference will be that the child is able to attend school and may continue. There may be cases in which it is apparent that the child cannot attend. Thus, children suffering from any of the manifestations of tuberculosis, such as enlarged lymphatic glands, or any of the chronic joint diseases to which childhood is so susceptible, are under no circumstances to be sent to school. On the other hand, no matter what may be the physique or general health of the child, if, after attending school for a while, it shows evidence of giving away physically, it should be immediately withdrawn. Schools, more than other buildings, have three things that are bad: First, bad ventilation; second, bad water supply; third, bad water-closets; and, in nine cases out of ten, the heating and lighting are faulty. These are all to be studied and remedied, if possible, before the child is allowed to enter the school-room. Long hours of mental work are to be discouraged and brief study hours encouraged.

In the school-life of children the great danger is complicating studies, that is, too many branches, rather than too much of any one branch.

Eyes. The child's eyes should have the attention of the parent from the beginning of school-life until it has been thoroughly established that study, reading, or similar work calling upon the eyes for protracted exertion does not weary them or produce headache or other reflex phenomena. There is nothing which produces more annoyance, gives rise to more difficulty, and more impedes a child's learning, than errors of refraction, which should always be corrected.

Baths. During childhood the baths need not be so frequent as during infancy. They should usually be tepid immersion baths about three times a week, and topical baths sufficiently often to insure cleanliness and comfort. Protracted bathing, either in salt or fresh water, is to be discouraged, especially in younger children. An occasional bath in the sea or in fresh-water streams may do no harm; it is frequent repetition or prolonged dabbling in the water that are to be condemned.

Young Adults and Adults. Shortly before crossing the line between youth and adult life, there develops a tendency upon the part of the individual to control his own movements, and when this point is reached the difficulty of applying rules is, in a large majority of cases, entirely overcome by personal wishes and individual taste. Besides this, the different vocations or professions may materially differ in the demands upon individual hygiene. During childhood and the earlier years of life, the lawyer's child requires the same hygienic surroundings as does the laborer's; if, however, when adult life is reached the lawyer's boy becomes a lawyer, and the brickmaker's boy a brickmaker, the same general laws of health could not be applied in both cases. When the brickmaker's day is done physical rest and mental exercise are most demanded; with the lawyer the reverse applies. It will thus be seen that we must consider two separate and distinct classes of individuals: those who live by mental exertion, and those whose lives are made up largely of physical work. In the first instance, the exercise demanded is such as to remove the mental cares of the long, busy day and devote the hours of recreation to the improvement of the physique. This will demand a horseback ride in the Park, a row, or a brisk walk; rarely gymnastics will fill the requirements. What has become popular in England among professional men, and is rapidly becoming popular in America, namely, bicycle riding, may be found efficient. Something which demands physical exertion sufficient to exercise the muscular system and give tone to the circulatory apparatus is needed; the cerebral centers are more or less exhausted and should be relaxed from strain; the activity of the skin is to be stimulated and the general nutrition of the system favored by reasonable physical exertion.

In the brickmaker, or other laborer, when his day's work is done the muscles are often in a condition of fatigue, and where it is desirable to develop the mental faculty, the opportunity is here offered—reading, a sail which requires no physical exertion, an evening excursion in a pleasure boat, where it is attainable and no rowing required, and such other recreations as afford physical relaxation or, at least, as nearly so as possible, with more or less active stimulation of the cerebral functions.

The food of the two will differ as essentially as the exercise; the one demanding large quantities of carbonaceous food for the production of heat and muscular force, and small quantities of nitrogenous food, while the other demands a diametrically opposite kind of food. The difference between the diet of the two will be taken up more fully when considering food.

Bathing is an essential hygienic feature, and aside from its therapeutic application may be resorted to for cleanliness, improvement of the skin, circulation, the improvement of nutrition, or the reduction of body weight. It is unnecessary to dilate upon the necessity of cleanliness as a hygienic procedure, and it will also be apparent that whatever occupation the individual may be in will demand a different degree and amount of bathing. Bathing affords a most admirable stimulus for the skin, improving the tone of its glandular apparatus, increasing the excretion which is carried on by its glands, and thus relieving the kidneys and liver of very much of their work.

There are many different forms of bath which may be used. The bath may be topical or general, it may be a sponge or an immersion bath, a spray, needle, or shower bath. With regard to temperature, it may be hot, warm, tepid, or cold. There are forms of so-called baths which do not use water at all; for example, sand baths, hot-air baths, and baths in which the atmosphere is impregnated with some medicament and gases. As examples of the last two we have oxygen and sulphurous acid baths, the latter being occasionally used for the destruction of the itch parasite.

Space does not afford opportunity for going into the consideration of baths in detail. Cold baths undoubtedly contract the capillaries of the skin, lessen the radiation of heat, diminish the cutaneous circulation, and congest the viscera. The application of cold locally has practically the same action although to a less degree. The hot-air and warm baths increase the cutaneous activity, and, while the cold bath may reduce the body temperature, hot air or hot baths ranging in temperature from 110° F. to 115° F. may produce a marked rise in temperature. Between these two extremes almost any intermediate may be found with a compromise reaction. Where it is desired to use the bath for cleansing purposes only, it should be what has been described as an indifferent bath; that is, neither hot nor cold to the sensations of the bather. In the use of extremely hot or cold or cool baths, each individual bather will have to make a selection which he finds by experiment best adapted to his physical condition. Cold baths have been recommended for the reduction of flesh, and seem to have some value in that direction. The Turkish and Egyptian baths are modifications of hot-air baths; the Russian steam bath is but another form for the application of heat and moisture. Sea bathing practically amounts to a salt-water bath, as it will be seen that the chlorid of sodium is the most important constituent in sea water. The Russian hot-air bath seems to favor somewhat the reduction of body weight ; it increases the specific gravity of the urine, the amount of urea and uric acid excreted. The hot air and hot vapor and the extremes of temperature in the immersion baths are to be avoided by all who are not physically strong, especially by the old with diseased blood-vessels, in whom no small number of apoplectic attacks have been brought on by bathing in extremes of temperature ; the same is true of individuals having a fatty heart.

The amount of bathing required by an adult will vary, as already stated, to an enormous degree. It would be safe, however, to state that not less than two or three immersion baths are to be taken each week, that they should not be prolonged, and experience will demonstrate for each individual the temperature it will be most wise for him to use. The daily topical baths of the hands, face, etc., are, of course, applied as necessity demands.

Special Hygiene. *The Eyes.* Care should be taken to prevent dust or dirt from gaining ingress to the eye. The eyelashes should be carefully looked after and kept clean, a matter which demands special attention. Individuals of the most cleanly habits will, when looking into a microscope, very often sweep their eyelashes across the eye-piece, depositing a trace of dust, thus showing that the eyelashes have not been properly cleansed. Inversion of the eyelashes should be looked to, and where they are falling out, care should be taken that they do not remain under the eyelids and give rise to irritation of the conjunctiva. In reading, proper light should always be selected, in which the essential features will be, sufficient light, without brightness or glare ; constant illumination of the page, without flickering or shadow. The light should come from over the shoulder and slightly to one side. The reading matter should be held steadily, and the letters should look sharp, clear, and distinct, and where the typography is perfect it should never be necessary to get closer to the page or project the page further away after prolonged study. When the above directions have been carried out and there is evidence of some effort being required to read constantly, it may be depended upon that there is some refractive error which should be corrected. Headaches, upon attempts to read or after protracted reading, are presumed to be due in no small number of cases to faulty eyes; these should, therefore, receive the attention of an ophthalmologist.

The Ear. The external ear should be cleansed with every bath, and accumulations of wax, dust, and dirt, or even the growth of some of the lower forms of molds, should be prevented by washing the ear out three or four times a week. Aside from careful cleansing at the time of bathing, where the occupation of the individual is such as to facilitate the ingress of dust and particles of flying matter into the ear, like sand and fragments of iron and sawdust, a small pledget of cotton may be inserted in the external auditory canal. Picking the ear is never to be permitted, as in no small number of cases the drum has been punctured, and scratches have been made upon the walls of the canal, giving rise to serious inflammatory complications.

The Teeth. The child should be taught as early as possible the necessity of keeping the teeth clean. Immediately after meals all food should be picked from between the teeth by means of a quill or wooden toothpick; metal should never be used. The teeth should be cleansed at least twice daily, and preferably oftener, by suitable brushing. In many parts of the South the colored people clean their teeth with brushes made by chewing the stubs of willow, a practice also carried out by the whites, and their teeth are certainly well preserved and kept beautifully clean. The writers are of the opinion that the stiff bristle brushes so commonly used lacerate and injure the gums, not infrequently loosening them from the teeth, and are in themselves inefficient means for removing accumulated dirt. The bristle-brush is probably the next best thing to a wooden brush and should be used where the wooden brush cannot be obtained. With dentistry so cheap and the work done so good, there is no cause for allowing decaying teeth to go on to ruin.

The Hair. Where the hair is kept cut short, as in men, it should be clipped at least once a month. The scalp should be shampooed two or three times a week for the removal of accumulated dandruff and as a stimulant to the cutaneous circulation. Medicated shampoos are rarely if ever indicated, and it will usually be found that a good soap will be more efficient than anything else that can be used. In women, greater care will have to be used in keeping the hair clean. Frequent shampoos are to be resorted to, the hair combed out once or twice daily, and allowed to thoroughly air. In the summer, when there is very much perspiration, a daily shampoo will be demanded. Large accumulations of hair with excessive weight in children not infrequently are conducive to headaches, and in some cases even more serious troubles.

The Feet. Foot-baths should be taken every day. The leather covering for the feet, which is now almost universally used, interferes with the escape of the vapors exhaled by the skin, and in order to maintain cleanliness, as well as a healthy condition of the cutaneous covering of the feet, a foot-bath every night should be used. The tendency to the development of corns and bunions and ingrowing toe nails is largely to be combated by sensible shoes. The cutting of the finger and toe nails is a matter of great importance, as ingrowing nails will certainly ensue if the ordinary methods be followed. The accompanying cut will illustrate the proper method for cutting the finger and toe nails.

FIG. 33.

Showing on the left the nail, cut square, as it properly should be; and, on the right, the nail is cut oval, and as a consequence the overgrowing of flesh.

Sex. It is not usually demanded that the young male, approaching manhood, receive any special instruction concerning the hygiene of the sexual organs. Other than cleanliness but little will be demanded. The dangers of abuse may well be pointed out, and the necessity for virtue be made a part of such training as best educates the mind. It is probable that the most pitfalls which entrap the unwary arise from one of two sources, either improper literature or unsavory companions, or both not uncommonly joining hand in hand. Exclude these, and but little danger may be anticipated from the developing sexual functions.

With the female, however, entirely different views must be held. The girl approaching womanhood should know the peculiarities which characterize her sex. She should be early apprised of the meaning of her catamenia and the hygienic laws upon which her health hereafter shall be based. Her habits and dress must be made a part of the training which her sex demands. The physical peculiarities of the individual will differ so widely that universally applicable rules cannot be formulated, but must rest upon the judgment and experience of elders. The educated and intelligent mother can here lay the foundation upon which will rest the health of the developing woman, while ignorance may endanger, if not destroy, the health, and with it the happiness, for the remaining years of life.

CHAPTER III.

CLOTHING.

From a sanitary point of view, the two important features to be considered are: First, *the materials of which clothing is made*, and second, *the method of construction*.

The materials most commonly used for the manufacture of clothing are *cotton*, *linen*, *wool*, *silk*, *jute*, the *skins of animals*, and *rubber*.

Chemical tests are resorted to in order to differentiate between materials above given and to detect the introduction of cheaper substitutes, or the substitution of a cheaper member of the group for a more expensive one, as cotton for linen. The material to be examined is first boiled in a strong solution of chlorid of zinc, and washed to remove the silk. It is then dried, and the loss by weight equals the amount of silk. Boil in liquor soda to dissolve the wool; again wash, dry, and weigh to determine the quantity of wool. The remainder is cotton or linen, and it may be determined which by treating with a solution of metallic copper in ammonia, the cotton rapidly dissolving.

The reactions may be tabulated as follows:—

	Liq. Potassa or Liq. Soda, Boiling.	Sulphuric Acid.	Picric Acid.	Nitric Acid.	Hot Concentrated Sol. of Zinc Chlorid.	Sol. of Metallic Copper in Ammonia.
Cotton, .	Unaffected	Gelatinous mass.	Slightly stained.	Slightly stained.	But slightly affected.	Dissolved.
Linen, . .	Unaffected	Gelatinous mass.	Easily remov'd	Slightly stained.		Slowly Dissolved.
Wool, . .	Dissolved	Unaffected.	Stained yellow.	Stained yellow.	Unaffected.	Swollen.
Silk, . . .	Dissolved	Dissolved slowly.	Stained yellow.	Stained yellow.	Dissolved.	Dissolved.

Microscopic Examinations. Chemical examination is best combined with microscopic examination; for this purpose a one-fourth inch objective of a good series will be needed. The material to be examined is "teased" or torn by means of needles into small fibers, or it may be carefully unraveled and untwisted; the fragments are then placed upon an ordinary glass slide and moistened with one of the following: Water, glycerin, glycerin and water (equal parts of each), a one per cent. dilution of liquor potassa or acetic acid, Farrant's medium. Glycerin and water give very satisfactory results, and do not act chemically upon any of the substances under consideration. A cover-glass is placed upon the fibers, any excess of fluid wiped off, and the microscopic examination conducted in the usual manner.

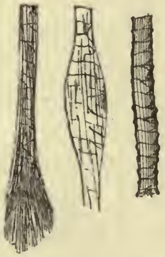
Fig. 34.

Cotton Fibers × 200 diam.

Fig. 35.

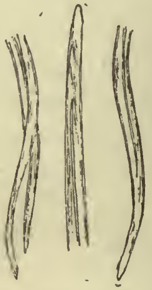
Linen Fibers × 150 diam.

Fig. 36.



Woolen Fibers × 200 diam.
Central fiber shows swelling and defective striation as observed in old wool and shoddy.

Fig. 37.



Silk Fibers × 200 diam.

Cotton fibers are about the one four-thousandth of an inch in diameter, flattened, and ribbon-like in contour; the borders are somewhat thickened and the primitive fiber shows about six hundred twistings or turnings to the inch. Often a canal exists in the fiber, which is, however, frequently filled with extractive matter.

Linen fibers are cylindrical instead of flat, as is cotton, the transverse diameter is less, and the fiber is pellucid ; the ends are ragged and uneven, and fine, branching fibrillæ extend irregularily outward from the juncture of the several segments of which the fiber is composed.

Wool. The fibers of wool are tubular, with longitudinal, transverse, and oblique striations. The transverse striation produces the appearance of the fibers being formed by the juxtaposition of segments ; while the effect of the oblique markings is to impart to the fiber a seemingly reticulated margin. The canal is not unusually obliterated. In old and worn samples of wool, the fibers lose to a great extent their striation, and the ends are resolved into the elementary fibrillæ. Frequently old fibers present quite a considerable swelling, in which the transverse markings are seldom distinct.

Jute. The fibers of jute are long and tubular, the outline uneven, and showing alternately small, irregular protuberances and constrictions. In the canals air bubbles are frequently seen.

Silk. The fibers of silk are finer than those of linen, they have sharply defined outlines, do not branch, are tapering, knotted, but less so than linen, and are diaphanous.

Shoddy. This is an inferior cloth, woven from old wool, torn into shreds, and refuse threads from the weaving of woolen and other like cloths, excepting silk. The microscope will discover its true nature, as the appearance of old and worn woolen fibers is characteristic.

Cotton wears exceedingly well and does not shrink. On account of the hardness of the fiber, its inability to retain moisture, and its ready heat conduction, cotton is far inferior to wool as protection against cold. It conducts heat less rapidly, possibly, than linen, and much more rapidly than wool. The rapidity with which it yields its moisture renders chilling liable to occur.

Linen has practically no sanitary advantage over cotton, and, being far more expensive, is much less used. Compared with cotton, linen is a somewhat better conductor of heat, absorbs more moisture, and yields it less rapidly ; it is less liable to absorb odors and outwears cotton. In the laundry, linen takes a higher gloss, a fact upon which its popularity depends.

Silk has some distinct advantages over cotton and linen, in that it is slightly more absorbent than either of the other two, has a greater porosity, and, therefore, is a poorer conductor of heat. It has been highly recommended for underwear, but its cost, combined with deficient durability, has not brought it into popular favor. The extreme lightness of silk is one of its most advantageous points, as, weight for weight, it is nearly four times as warm as wool, and possesses equal absorption and conduction properties.

Wool. The advantages which wool possesses as a material for clothing are its poor heat conduction, the readiness with which it absorbs aqueous vapors, such as that emanating from the skin, and the gradual evaporation of the moisture, which precludes the chilling of the surface of the body. This feature of absorption and yielding up of the water is largely modified by the method of weaving—in other words, the texture of the cloth; this will vary a great deal, as some wools are very much finer than others, the fineness depending upon the size, density, flexibility, and length of the fibers. It would also appear that the color has something to do with the amount of moisture which a given sample will absorb. The great disadvantage in woolen clothing, more particularly that worn next to the skin, is its great shrinking properties. The slowness with which wool yields up moisture, and its poor conduction of heat, make it vastly superior to cotton or linen where these features are desired.

Merino. This is composed of from twenty to fifty per cent. wool "carded" in with the cotton. It is now made up so as to combine very nicely some of the advantages of both. and is a most excellent compromise where it would be too warm for the use of woolen clothes and too cool for the use of cotton. It is also better than linen where there is an excess of perspiration to be absorbed, and, in this respect, proportionately poorer than wool in direct ratio to the amount of cotton which it contains. Merino does not shrink, as does wool, and stands unskilled washing much the better.

The Skins of Animals. These may be worn untanned, in which case they are known as furs, but when tanned, as leather. The advantages which they possess are: they are poor conductors of heat, do not permit the ingress and egress of air, and are, therefore, extremely warm. As they retain the vapors given off by the skin and prevent ventilation of any garment which may be under them, they are, for sanitary reasons, objectionable. On account of the above objections, they are not to be recommended as clothing unless extreme cold should demand it. So far as known, we have no substitute for leather as a covering for the feet, and, although the above objections hold good, there is nothing less open to criticism.

Rubber is used exclusively as a water-proof article of dress. Its only good quality is that it prevents the ingress of moisture from without, the reverse being equally true, it prevents the egress of moisture from within, and is therefore highly objectionable and should never be worn for any considerable length of time. By reason of these objections it has not been introduced into the French army, as it is believed that, with properly constructed woolen clothing, it is better for the soldier to get wet than to wear rubber.

Specific Considerations. For protection against cold wool is to be preferred; especially is this true of underclothing; and where wool is not sufficient it may be reinforced by leather, furs or, rarely, water-proof overclothing.

Heat. It is to be remembered that thickness and texture have very little to do with protection against heat and, all other things being equal, it will be found that the color will influence the absorption of heat rays more than any other consideration. Results based upon experiment may be briefly summarized as follows: Direct solar rays are but slightly absorbed by white goods; next in efficiency comes gray, yellow, pink, blue, and mixtures of these colors, gradually progressing toward black, which is most absorbent of all.

Winds. Rubber, leather, wool, linen, and cotton in about the order named. Where there is abundant perspiration, materials wholly or partly woolen are recommended.

Odors. As a prevention against the absorption of odors, it would appear from Starkes' experiments that color and the hygroscopic reaction of the fabric are the most important features, the relation to odor absorption being practically the same as the absorption of direct solar rays.

Objectionably Constructed Clothing. It cannot be possible to go into the construction of garments in anything like a specific manner; besides the demanded brevity, we have to consider that the evolving cycle of fashion, to which, unfortunately, all humanity is more or less a slave, would wreck the best laid plans for hygienic construction. Dress reformers have agitated this matter and worked at it faithfully and conscientiously without any apparent success. Spasmodic deviations from the general rule are of worse than questionable utility. The abandonment of the corset or the narrow-toed shoe for a week or a season is a step in the proper direction, but where one climbs only to fall, the shorter the ascent the less harm will be done by the descent. There are, however, some features which demand the attention of the careful physician, and to some of these we propose to briefly allude.

The wearing of the corset has been criticized from all sides, as far as professional views could be expressed. The surgeon, on account of the liability to the development of tumors of the breast and the possibility of inducing hernia; the obstetrician, upon the theoretical ground of displacement downward of the pelvic viscera; the medical man, with a probably better reason than any of the others, upon the ground of inducing torpidity of the digestive functions, atrophy of the accessory muscles and the abdominal walls, the interference with respiration, and the possible tendency toward the development of nervous conditions associated more or less intimately with some of the above-mentioned factors. There is another view to us apparent. The pressure is begun early; it is protracted and must of necessity interfere with the development of all those organs upon which pressure is made; the circulation must be interfered with and the tendency toward the development of varicose veins and other conditions in the limbs of the female depending upon obstructed blood-flow must be largely derived from some of the effects laid at the door of the corset. There can be no doubt that the woman who wears a corset is comfortable, and to go without it would be a temporary discomfort; and the same may be said of the African savage, who, to go without her ring in her nose and ears and lips, would feel temporarily great discomfort. Added to the corset curse, we have the suspension or carrying of all clothing below the waist, either from or upon the hips, thus adding weight to the pressure already borne by the abdominal muscles and the crest of the pelvis. There can be no doubt that the development of all organs implicated in the wearing of clothing is more or less retarded by the pressure exerted and the interference with free movement, a fact borne out most fully when one studies the physical development of the savage not so encumbered, in which, all other things being equal, the nuder races afford the best types of physical development. This is to be explained almost entirely upon the basis of interference with function, and, hence, any clothing which does not interfere with the function of organs will most nearly approach the ideal of the true dress reformer.

Not only does the wearing of improperly constructed clothing lessen functional activity for the time worn, but its continuous wear leads to, first, the atrophy and, finally, the disappearance of histological and anatomical structures whose functions are not easily replaced. Where one recognizes physical as well as mental evolution, the outcome must be to the final injury of the race.

What is true of the corset is equally true of the encircling garter and all similar appliances which by pressure interfere with the circulation or exert direct compression on the muscles, etc., leading to atrophy of anatomical elements. The retardation of the circulation not only conduces to the production of conditions above pointed out, but leads to the deposition of fat. Thus it will ever be found that where women are lacing to secure the reduction of obesity, the obesity increases in direct proportion to the degree of lacing which is resorted to. There is not a medical man of extensive practice who has not recognized this fact, and until the theory of obstructed circulation was brought forward no explanation of the phenomena could be adduced to fully accord with the facts.

Next to the corset and tight-band curse, the modern shoe is probably deserving of most censure. In this error women lead the way, although they are by no means the vainer of the two sexes. At the very earliest period of human life this modification of Chinese barbarism is encouraged, and the developing foot, with all its complex muscular, osseous, nervous, and circulatory appurtenances, is pinched and distorted into shapes never found in all the monstrosities that nature has conceived and brought forth. The beauty of the plantar arch converted into a flattened surface, the little toe crowded under its neighbor, and its neighbor pinched beneath the next toe, the entire foot shot forward and the toes doubled up by that abomination of a high heel, which, by precluding heel-and-toe walking and artificially elevating the posterior extremity of the foot, leads directly to progressive wasting of the muscles of the calf. Following the atrophic changes in the leg, we have that "mincing" gait now so commonly observed on the street and in the parlor. In order to make the foot appear small, the shoe-heel is placed far in front of the bony prominence intended for receiving the weight, and the resulting pressure leads to atrophy of the plantar ligaments and the gradual dissolution of the arch upon which feminine beauty once prided itself.

Baldness. As an example of improper clothing being conducive to the development of disease, we have baldness as a most admirable example. The rareness of this disease among women and savages is largely due to the fact that the head is not encased in an unventilated covering, the circumferential and nervous supply not impeded, as is the case in the so-called civilized man. There can be no doubt but what this factor is the cause of a large percentage of baldness, and it may be further asserted, upon the very best of grounds, that man is not likely to modify his headgear to a sufficient degree to arrest the rapidly spreading malady.

CHAPTER IV.

FOOD.

We may consider as food any substance which is capable of replacing or constructing tissue, or which enters into the development of any of those complex vital processes which we designate as functional activity, energy, heat, or its equivalent, force.

It will thus be seen that this definition of necessity embraces air and water. By mutual consent, however, writers have considered these separately, at the same time with the distinct understanding that they are foods.

There are two sources to which we may look in order to arrive at a general basis upon which to estimate, first, the materials demanded by the economy and, second, the quantity of food required. Of these the first may be obtained by estimates based upon the composition of the blood and other tissues, thus giving the material demanded. These calculations may be upon the proximate principles or upon the ultimate elements of which the tissues are composed. Given the materials demanded, the quantity is estimated with much less accuracy by determining the amount of food necessary to produce, by the process of combustion and oxidation, the different excreta which are given off by the human organism.

Perfected chemistry has shown in a very definite manner the amount of ultimate equivalent given off by the economy, and, with fairly accurate observations and reasoning, the probable source of each.

All tissues being derived from the blood, the body nutrition and function being maintained through the same agency, and as the blood is supplied from the food, it is reasonable to presume that the same elements should be present in all three.

Table showing the proximate composition of the blood:—*

Water,		781.600
Globulin,		135.000
Albumin,		70.000
Fibrin,		2.500
Serolin,		0.025
Cholesterin,		0.125
Sodium,	Oleate Margarate Stearate	1.400
Potassium, Sodium, Magnesium,	Chlorid	3.500
Potassium, Sodium,	Carbonate Sulphate Phosphate	2.850
Free Soda,		
Magnesium,	Sulphate Phosphate	
Calcium phosphate,		
Iron,		0.550
Extractive undetermined,		2.450
		1000.000

It will be seen by referring to the above table that the blood contains water, chlorid of sodium, phosphates of magnesium and potassium, and other inorganic salts, which from a superficial view would not be included as foods. They are, nevertheless, useful in the animal economy for replacing tissue and carrying on function, and hence, they are foods.

While the proximate principles indicate the materials to be supplied, they do not present the food as actually consumed. They are the vitalized foods proper, and to these must be added the accessory foods and condiments.

Source and Quantity of Food. The organic foods include, as man is an omnivorous animal, selected products from all kingdoms. From the animal kingdom we utilize the flesh and milk of the mammalia, the eggs and flesh of the ovipara ; from the vegetable kingdom, the seeds of plants (cereals, legumes), roots, herbs, fruits, etc. The inorganic foods come largely as component parts of the organic and also as condiments, salt affording an example.

The proximate principles found in tissues are supplied by similar principles in food, and as all vital action demands the destruc-

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* After Chapman.

tion of tissue to produce heat and force, food must supply the requisites. For these reasons it was at one time believed that all foods might be divided into those supplying tissue wear or waste, and those utilized for combustion and the production of heat and its physical equivalent—force. Such a division is no longer believed to be fully in accord with the most modern physiological observations, but the subdivisions of food, which arose during the idealization of food calculation, are still retained. These are the food proximate principles which supply tissue proximate principles. Of these there are four groups: 1st. The foods in which nitrogen forms the most prominent factor. In this group we include albumin, syntonin, myosin, fibrin, serolin, globulin, etc. The members of this group are known as *proteids*, *albuminates*, *albuminoids*, *nitrogenous compounds*, and under similar designations, signifying either their origin, process of assimilation, or ultimate composition. In the latter they are reasonably uniform, affording about 17 per cent. of nitrogen. 2d. The *fats* or *hydrocarbons*, including both animal and vegetable fats, have an almost uniform composition in which carbon forms the most important factor. 3d. The *carbohydrates*, in which carbon is again the most prominent factor, combined with hydrogen and oxygen, the latter two elements in the proportion to form water. To this group belong the starches and saccharin foods. The intimate association, both chemically and physiologically, existing between the latter two groups has led a number of physiologists to classify them together under the general head of fats and starches. 4th. This group includes the *inorganic compounds* and demands no comment. The relative value of the members of the four groups may be summed up in ultimate composition approximately as follows :—

1 oz. albuminate contains 70 grs. of nitrogen,	212 grs. carbon.
1 oz. fat contains	336 grs. carbon.
1 oz. carbohydrates contains	190 grs. carbon.

ANIMAL FOODS.

Milk, as pointed out by Prout and others, affords one of the best forms of food and contains within itself all of the essential elements necessary for the production of tissue, heat, force, and function. It includes all four divisions of food to which we have referred. If the accompanying formulæ for human milk and cows' milk be closely examined, the relation existing between the constituents of the blood as already given and the elements present in milk will be evident:—

COMPOSITION OF MILK.

HUMAN (*after Chapman*).			COW (*after C. Cameron*).		
Water,		902.717	Water,		870.000
Butter,	25.000		Fat,	40.000	
Casein,	29.000		Casein,	41.000	
Sugar,	37.000		Sugar,	42.800	
Lacto-protein,	1.000				
Salts,	4.283		Salts,	6.200	
Solids not fat,	71,283		Solids not fat,	90.000	
Total of solids,		96.283	Total of solids,		130.000
		1000.000.			1000 000

Gases in Solution	Oxygen,	1.29	30 parts per 1000 in volume.
	Nitrogen,	12.17	
	Carbonic acid,	16.54	

Milk probably represents the only food upon which alone life can be maintained for any prolonged period, and the quantity necessary will vary enormously under different circumstances. The writers are aware of a patient who lived three years upon from three to five pints of milk daily, and a patient in the Hospital of the Jefferson Medical College, suffering from carcinoma of the gullet, received three pints of milk daily and gained considerable weight and strength during the period of thirteen months. The quantity of milk which will be necessary for food will vary with the quality of milk, the surrounding temperature, humidity, digestion, and other factors; but as a general rule it will be between fifty and sixty ounces. The writers are inclined to think that this estimate is a little high, but at the same time it has been found necessary at times to reach the latter amount.

Milk has the additional advantage in that it can be predigested to a certain extent. Thus the availability of the food value of milk is greatly enhanced by peptonizing or by fermenting, as is done in preparation of koumiss and kefir. Milk also has the advantage that it may be preserved for a considerable length of time if proper care be used. Thus, if milk be entirely sterilized and kept in closed vessels, it will be found valuable for food even after several days. There can be no doubt that, by reason of its excellence as a culture medium for microörganisms, milk should always be sterilized in the summer, and preferably even in the winter months.

From rather prolonged observation at the Philadelphia Sanitarium for Children, the writers feel convinced that no artificial food is to be compared with sterilized milk for the feeding of infants. It is our opinion that where sterilized milk has not given satisfaction as a food, the sterilization has been delayed until fermentation has set in, and that its efficiency as a food was interfered with by the presence of bacterial products developed before the heat had been utilized for the killing of the bacteria.

Milk may be best preserved by some of the forms of condensing by evaporation. Of these there are several, each of which presents some distinct advantage. Milk preserved by evaporation alone, unless the evaporation be done to dryness, does not keep well after the sealed cans have been opened. However, milk preserved by evaporation and the addition of sugar keeps very well, even after the cans are opened.

The one great objection to milk is the danger of its contamination and adulteration; it is the only animal food which we habitually eat raw, and, therefore, being uncooked, is more likely to contain elements of danger than were it possible to properly cook it. The most common adulteration of milk consists in the addition of water. Battershall states that until 1883, in the city of New York, of the 120,000,000 of quarts of milk annually brought into New York city, there was an intentional dilution by the addition of 40,000,000 of quarts of water. Of two hundred and forty-one samples of milk examined by the Public Analyst of Eastern Massachusetts, over one-fifth were watered. It is, therefore, to be seen that the prevalence of watered milk is very common. The dangers arising from watered milk are two-fold. In the first place, we have the lessened nutritive value of the food, as a matter of course; and second, the water which is brought in with the food is likely to contain infective material, thus poisoning the milk prior to its distribution. As an illustration of this, we have typhoid fever, which may, undoubtedly, be communicated by adulterated milk; and it is easy to see that malaria and allied conditions could be spread through milk which has been adulterated with water containing the organisms of paludism or other parasites. Another very common method of adulteration consists in extracting a portion of the cream; this is accomplished at creameries constructed for the purpose.

Tyrotoxicon. Certain poisonous conditions are known to develop in milk, but as yet few of these have been completely worked out. Tyrotoxicon poisoning has been fully studied by Professor Vaughn, who has isolated the poison, not only from milk and cheese, but from ice cream, which has given rise to tyrotoxicon poisoning. The material itself is probably a product of bacterial development.

Contagious Diseases. The question has arisen and remains unanswered, whether the contagious diseases of childhood, such as measles, scarlet fever, etc., have their analogue in the diseases of the milch cow. If such be the case, the possible propagation of such diseases from diseased cows would be, of course, established. The investigations into the outbreak of scarlet fever from milk supplied from cows suffering from a rather peculiar disease (Haddon's milch cow disease) was negative in its results.

That cowpox is more or less intimately related to smallpox, seems to be well established; whether such be the case in allied diseases remains to be proven.

Bacterial Diseases. Tuberculosis can undoubtedly be propagated through milk from cows suffering with the disease, and it is not improbable that anthrax, actinomycosis, and other members of the bacterial diseases might be spread through milk containing microörganisms, which act as the cause of such diseases.

Milk from all animals suffering from any diseases of bacterial origin should be rejected for food; for although it may be impossible to demonstrate the presence of the bacterial agent in any given sample of milk, it is probable that the cow suffering from the disease will transmit the bacteria.

Souring and Curdling. Some very interesting questions have arisen as to the souring and curdling point of milk. It has been maintained that souring and curdling were identical processes; again, it is believed that curdling is a physiological process in milk, due to gaseous changes or the yielding of some constituent in the same manner as blood clots, and that souring is of necessity a bacterial process. While this matter has not been thoroughly investigated, there are abundant reasons for believing that, as it ordinarily occurs, it is a complex process. Sterile milk does not coagulate or clot in the same manner as does unsterile milk. The theory as ordinarily given for milk becoming sour is that the carbonic acid gas in the milk is given off, and the absorption of oxygen from the air favors the development of lactic acid from the casein. It is not at all probable that this theory is correct; the bacterial agent most common in milk, bacillus acidi lactici, in its growth gives off carbonic acid and takes up oxygen, and one cannot infer that such a process could be spontaneous. Bacteria are probably the exclusive sources of lactic acid in milk.

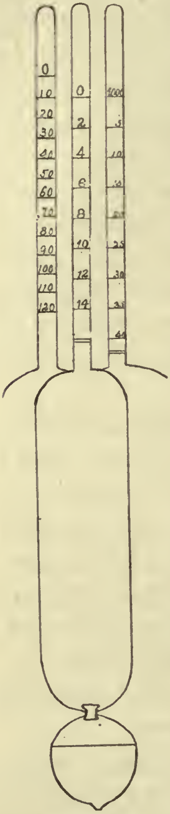
Milk will rapidly absorb foul odors. In improperly kept dairies, the milk very promptly takes up large quantities of ammonia, sulphureted hydrogen, and other gases. These gaseous materials held in solution are not, of necessity, injurious; they are, however, indicative of such an unsanitary condition of the utensils, or faulty collection and storage of milk, as to render it unsafe for food.

No sanitarian can vouch for the quality and healthfulness of milk unless the cows, dairy, containers, all coming in contact with the milk, can be kept under observation. The purity of milk is more dependent upon these than upon the percentage of cream or the quantity of solids. Legislation which fails to consider the cow and her environment, the handling and storage of milk, is faulty, no matter what it may adopt as the requisite percentage of solids or cream which salable milk must contain.

When milk is watered, it becomes, of course, the carrier of whatever diseases the water itself is liable to transmit.

Milk Examination. For determining the presence of water in milk, a form of hydrometer, known as the lactometer, is in general use. The accompanying diagrams of lactometers will give an idea of their essential features. The lactometer used in Boston consists of an ordinary hydrometer, graduated in degrees from 1000 to 1040. In New York a similar instrument is used, except that instead of 1000, the mark is made 1, and the graduations are extended up to 100, which would occupy the point of 1.029 taken as a minimum density of unadulterated milk. Above this, the graduations extend to 120, giving an equivalent of 1.0348 of specific gravity. Observations with the lactometer are made at a constant temperature of 15° C. or 59° F., and note should be made of the color and consistency of the sample. As the graduations are made in the New York lactometer, the percentage of water is easily estimated or is properly read off from the lactometer; *e. g.*, if the lactometer registers 70, it indicates that there are 30 parts of water and 70 parts of unadulterated milk; this method of reading affords a distinct advantage over the calculations necessary with the ordinary hydrometer. A lactometer has been proposed which reads off directly the amount of solids, and the graduations are shown in the accompanying illustration. O represents the specific gravity of 1000; that means, of course, that the fluid examined is free from solids, while the reading of 14 indicates 14 per cent. of solids, so that the graduations have an immediate significance and do not demand any calculation.

Fig. 38.

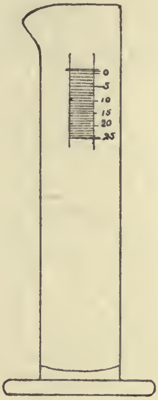


Lactometer.
Stem on the right graduated as used in Boston. Stem on the left shows graduation adopted in New York. Central stem graduated to show percentage of solids.

The *percentage of total solids* considered compatible with unadulterated milk ranges between twelve and thirteen per cent. by weight. This estimate includes the fatty and non-fatty solids. The fatty solids are usually given as from 3 to 3.7 per cent. by weight; the non-fatty solids from 8.5 to 9.5 per cent. by weight.

There is no practical choice between these three instruments except as matters of individual taste. The results attainable by this method are not absolute; they, however, in intelligent hands afford most excellent clues, and the method is entirely applicable where prolonged volumetric analysis would not be possible. The objections to the lactometer have been founded for the most part upon the fact that milk which contains a large quantity of cream will give a lower reading and therefore indicate poorer milk than a similar article containing very much less cream, but, as Battershall expresses it,—"With the exercise of ordinary intelligence, this contingency seldom arises, as the proportion of cream required to reduce a specific gravity to that of watered milk would be more than sufficient to obviate any danger of mistaking the cause of decreased density."

FIG. 39.



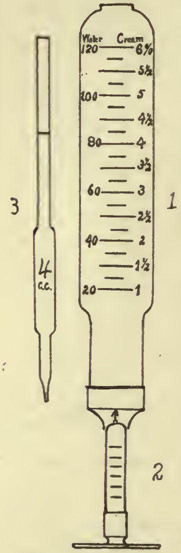
CREAMOMETER.

The quantity of fat or cream which milk should contain varies considerably, ranging from 3.5 to 5 per cent. of the entire bulk. Until recently there has been no accurate instrument for estimating the amount of cream which is present in a given sample of milk. Two instruments which have been most used are the creamometer and Feser's lactoscope.

The *creamometer* consists of a cylindrical, glass hydrometer jar, having a depth of not less than eight inches and preferably ten, with a transverse diameter of not more than one and one-half inches. Beginning about one-half inch from the top, the jar is graduated downward in percentage of volume for the whole jar. After the milk to be tested is poured into the jar as high as the upper line of the graduation, marked 0, the jar is then set aside in a cool place for twelve hours, when the quantity of cream may be read off in per cent. as indicated in the adjoining scale. The instrument is only approximate. It has been found of use by confectioners who desire to estimate the quantity of cream in milk preparatory to making ice cream.

Feser's Lactoscope is an instrument which apparently gives reasonably reliable results. It consists essentially of two parts, a cylindrical tube six inches in length and $1\frac{3}{8}$ inches in diameter. At the upper end it is rapidly contracted to $\frac{1}{2}$ inch in diameter. At the lower end, a $1\frac{1}{2}$ inch cylinder is drawn out in a prolongation two inches in length and $\frac{7}{8}$ of an inch in thickness, at the termination of which is fitted a metal cap perforated by a single opening $\frac{7}{16}$ of an inch in diameter. Beginning at the lower portion of the larger diameter of the cylinder, a graduation is made based upon two factors: First, a graduation indicating the amount of water which has been added in order to bring the milk to the point marked; and, second, the figure, at the other end of the graduation mark, indicates the percentage of cream. The second part of the lactoscope consists of a pedestal accurately ground to act as a stopper to the bottom of the jar. There is mounted on this pedestal an enamel glass rod $\frac{3}{8}$ of an inch in diameter, which extends upward into the contracted portion of the cylinder for 1¾ inches. On the side of the enamel glass rod there are six lines engraved and blackened; the distance between the lines and the length of each line is $\frac{3}{16}$ of an inch. Accompanying the lactoscope there is also a pipette, which is graduated for 4 c. c. To use the lactoscope, the milk to be examined is well shaken and thoroughly mixed, after which the pipette is filled and emptied into the lactoscope, care being taken that the metal base is pressed securely into the cap so that leakage will not occur. Water is then gradually added to the milk with frequent agitation until the mixture becomes sufficiently clear for the black lines on the rod to be discernible. When these can be plainly seen and counted, then all that remains is to read off under the percentage of cream column the percentage of cream which the given sample contains. This instrument has been found reasonably accurate and affords an easy and rapid method of estimating the percentage of cream.

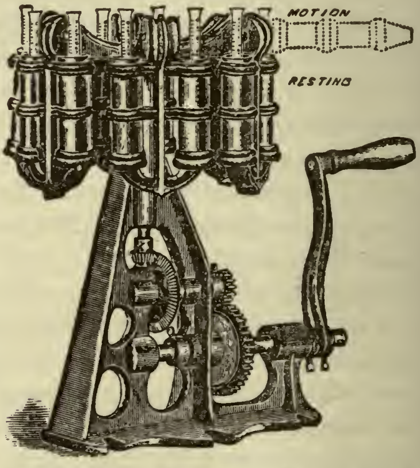
FIG. 40



FESER'S LACTOSCOPE.

1. Graduated cylinder, into which fits the base. 2. Pedestal with attached engraved rod. When in place this fits accurately the metal cup on the bottom of part 1, and the engraved rod reaches almost to the upper limit of the contracted lower end of part 1. 3 Pipette for measuring the milk.

FIG. 41.



BEIMLING PATENT MILK TEST. Machine used in making test.

Another method for estimating the percentage of butter-fat in milk consists in the use of an apparatus patented and known as the "*Beimling Patent Milk Test.*"* The apparatus used consists of a centrifugal-acting machine, test bottles, and pipettes, as shown in the accompanying illustration. The reagents used are known as Compound No. 1 and Compound No. 2. Compound No. 1 is composed of equal parts of amyl alcohol and strong hydrochloric acid. Compound No. 2 is dilute sulphuric acid. The following are the instructions for the making of the test, as issued by the patentee:—

When possible, make tests in a warm, comfortable room.

Great care should be exercised in getting the sample of milk to be tested.

If from pail or other vessel, stir well before taking sample. If from weigh can, extract the sample immediately after the milk has been emptied from the farmer's can into the weigh can. For convenience in handling, the samples should be put into heavy one and one quarter by five-inch test jars. Enough milk should be taken to fill the jar about three-fifths full. Before the samples are taken from the test jars into the test bottles, the milk should be thoroughly mixed up. This can be accomplished by pouring from one jar to another several times, or by drawing a milk pipette full of milk and quickly discharging it into the test jar before the cream has time to raise very much. If samples of curded, sour milk, are to be taken, mix in five per cent. of strong ammonia water, which will dissolve the curd. When the ammonia water is used, the final result should be increased by five per cent.

Measuring the Milk. After the milk from which the sample is to be taken has been sufficiently mixed, fill the 15 c. c., or milk pipette, by placing the lower end in the milk and sucking at the upper end until the milk rises above the mark on the stem, then remove the pipette from the mouth and quickly close the upper end of the tube by placing the thumb and index finger upon it. Carefully relieve the pressure, allowing the milk to settle, until the upper surface of the milk is even with the mark on the stem. Next place the lower end of the pipette in a test bottle and discharge the contents by blowing in the upper end.

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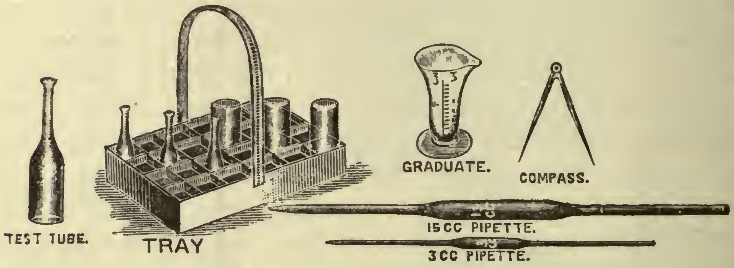
* Leffmann-Beam method.

It is best to clean the pipette by drawing water into it after each test. If several tests of the same milk are to be made, the milk should be thoroughly mixed after each sample is taken.

Adding the Acid. After the milk has been measured into the test tubes, add 3 c. c. of Compound No. 1. This is accomplished by the use of the small, or 3 c. c., pipette, and in the same manner as the sample of milk is taken. Care should be taken not to draw the acid into the mouth. While there are no injurious effects attendant upon getting the acid into the mouth, it is not pleasant, and by using a little care can easily be avoided. After the addition of Compound No. 1, fill the bottle up to within an inch of the neck with Compound No. 2; shake until the curd or casein is entirely dissolved by chemical action. Then fill the bottle with Compound No. 2 to the 0 mark. Shake again and place the bottle in the machine, which should be whirled from seventy-five to one hundred revolutions of the crank, consuming in time from one to one and one-half minutes. The pockets should at all times, before whirling, contain the test bottles, filled with either the mixture for test or water. This is to preserve the equilibrium of the machine. After subjecting the tests to the centrifugal process, as above described, the butter fat will be shown in a perfectly clear condition in the neck of the tube.

Fig. 42.



Accessories for Beimling Patent Milk Test.

Test-tube, or test-bottle:—Capacity, 33 c. c., with long neck accurately graduated so that each division is equivalent to one-tenth per cent., by weight, of butter fat. Tray for convenient cleaning and drying of test bottles. 15 c. c. Pipette, for measuring milk. 3 c. c. Pipette, for measuring reagent. Compass, for accurately determining the reading on the stem. Graduate, for measuring and handling milk, reagents, etc., in larger quantities.

In case the oil is cloudy, replace the test tube in the machine and whirl a moment longer.

With very rich samples of milk or cream, it may be necessary to dilute with water, one-half. In this case double the result.

Milk Preservatives. Milk is artifically preserved or its curdling and souring retarded by the addition of borax, boric acid, salicylic acid, or other antiseptics, some being sold, separately or in combination, under trade names, such as "preservoline," etc. In order to detect boric acid, the milk is rendered slightly alkaline, evaporated to dryness and incinerated; the residue is dissolved in hydrochloric acid, filtered, and evaporated to dryness on a water bath. Hydrochloric acid is again added, mixed with tincture of turmeric, when a vermilion or cherry-red color will develop if boric acid be present. In order to detect salicylic acid, the milk is coagulated by the addition of a small quantity of acid mercuric nitrate. The whey is then filtered off and shaken with a mixture of ether and petroleum spirits, equal parts. This mixture takes up the salicylic acid and by allowing the solvent to evaporate the presence of the acid may be demonstrated by the addition of ferric chlorid, which will give a purple color.

Coloring. Among the coloring matters which may be present in milk we have annato, carotin, turmeric, Martius' yellow, and naphthol yellow, and other members of the coal tar group. Martius' yellow is poisonous, but is rarely used. Colorings used for milk are also used for producing that rich yellow so much desired in butter. Milk may be colored by the growth of colored or color-producing bacteria. All coloring in milk, whether introduced by the dealer or infectious in origin, should condemn the sample.

Butter and Buttermilk. *Butter* is prepared from the fat of milk by allowing acid fermentation to go on, releasing the fat from the casein emulsion, and then by churning until the fat globules run together or coalesce into a solid mass, which is butter. The remaining fluid is known as buttermilk.

Buttermilk is nutritious, and to many a palatable, thirst-relieving drink. The process of fermentation has partly converted the lactose into lactic acid, and thus altered, the coagulating property becomes almost nil. Pavy gives the composition of buttermilk as follows:—

Water,	88.0
Nitrogenous matter,	4.1
Fatty matter,	0.7
Lactine,	6.4
Salts,	.8

The digestibility of buttermilk is one of its most valuable properties, which, added to its thirst-relieving quality, makes it often more useful as a food than fresh milk with unaltered casein.

Butter. After removal from the buttermilk butter is thoroughly washed in order to remove all the casein; the more thorough the washing the better the keeping properties of the butter. The preservation is facilitated by the addition of salt, the percentage of which should be between 1.5 and 3 per cent. Where butter is to be utilized or sold as fresh, no salt is added; where salt has been added, the butter is sold as salted butter. The composition of butter as given by König is as follows:—

Fat,	87.0
Casein,	0 5
Milk sugar,	0.5
Water,	11.7

The amount of water in butter should not exceed the limits here laid down, and where a larger amount is present it may be inferred that it is worked into the butter in order to increase its weight; thus butter may be made to take up 20 per cent. in the fresh condition and from 25 to 28 per cent. when salted. The presence of such a percentage of water in butter may be detected by melting the butter in a long glass tube, when the water will lie at the bottom. A very small percentage of water is suspicious, as indicating the admixture of foreign fat. The percentage of casein in the butter varies within very narrow limits normally. Artificial methods are, however, introduced to increase the butter yield from milk by securing a coagulation of a part of the casein and retaining this with the fat. What is known as "black pepsin," a mixture consisting of rennet, salt, and a small quantity of bicarbonate of soda, is added to the cream before churning, causing a certain amount of casein to separate and be collected with the butter, thus increasing the weight of the butter mass and making the milk yield a heavier percentage. As the butter fat is also partly emulsified, an additional weight of water is secured, thereby increasing the weight yield. Casein may be detected by melting the butter in a tall test tube as for the determination of water, or if the fat be extracted from the butter by means of ether the casein will be found at the bottom. It should never exceed .75 per cent. The casein appears to act in its decomposition as a ferment which liberates the fatty acids, and hence butter rich in casein keeps poorly. It is probable that casein decomposes more rapidly by reason of the readiness with which bacterial growth is sustained upon it.

Butter fat consists of volatile and non-volatile fatty acids, combined with glycerin. The volatile acids are butyric, caproic, capric, and caprylic. The non-volatile acids are stearic, palmitic, and oleic. The butter fats vary in quantity between 85 and 90 per cent.

The mixing of old and fresh butter, the sugaring and oversalting of butter, are "tricks of the trade;" the sugar is sometimes used as a preservative, either alone or mixed with the salt, preferably the latter.

The adulterations of butter not already considered consist for the most part in the addition or substitution of foreign fats. Thus the fats of beef, mutton, and pork may be worked up into butter or butter substitutes, or some of the vegetable oils may be added. These substitutes are known under various names, as butterine, margarine, oleo, oleomargarine, "oleo mixtures," and "straight oleos."

Butter Substitutes. There has been bitter controversy over the wholesomeness of these members of the so-called made foods. It seems probable that the entire cavil may be settled by a consideration of three factors: 1st. The purity of the materials out of which the substitute is manufactured. 2d. The method of manufacture. 3d. The sale of the product as a substitute and not as genuine butter. The opposition has not been fair. It has been largely the producers of butter who have antagonized the production of substitutes which threatened to drive the pure article out of the market, and thus rob them of an honest living. Tax was heaped upon all "oleos;" regulations, good, bad, indifferent, and unnecessary, were brought forward, not, as was claimed, to protect the consumer, but, in reality, to protect the butter producer. Had sanitary authorities dared, as they should long ago have done, to place such much-needed restrictions upon the genuine article, the very leaders in the crusade against substitutes would have been the loudest objectors. Now that the heat of the controversy is over and experience has disproven many claims advanced for or against and developed only facts, the cooler heads seem to view the proposed substitutes as real advances, in that they are just what Professor Atwater claimed for them as long ago as 1886:—

"1. The common kinds of imitation butter, oleomargarine, butterine, etc., when properly made, agree very closely in chemical composition, digestibility, and nutritive value with butter from cow's milk.

"2. In fulfilling one of the most important functions of food, namely, that of supplying the body with heat and muscular energy, they, with butter, excel in efficiency all, or nearly all, our other common food materials.

"3. Considering the low cost at which they can be produced, as well as their palatability and nutritive value, they form a food product of very great economical importance, and one which is calculated to greatly benefit a large class of our population whose limited incomes make good dairy butter a luxury.

"4. Imitation butter, like many other manufactured food materials, is liable (but in actual commerce has been found not to be so) to be rendered unwholesome by improper materials and methods of manufacture. It is also open to the especial objection that it is largely sold as genuine butter. The interests of the public, therefore, demand that it should be subjected to competent official inspection, and that it should be sold for what it is, and not as genuine butter."

Examination of Butter. The amount of water should be estimated; the amount of casein detected as already given; excessive salting will be discernible by the taste; the butter should have only that pleasant odor characteristic of butter; it should not be rancid, and when "worked" up with water should yield no color. Butter is supposed to have been adulterated with starch, but it is not probable that in this country such is ever the case; but should starch be introduced it can readily be detected by iodin. The identification of good butter is dependent upon the percentage and quality of the fat present, and although a large number of tests have been originated for the detection of extraneous fats, but few of them have any merit, and probably only one is deserving of confidence. The microscopic examination, including the polariscope, is unreliable. The determination of the melting point, solidifying point, the sinking point, and the specific gravity do not seem to promise very gratifying results. For the estimation of volatile acids or fatty acids, the following is recommended by the Association of Official Agricultural Chemists:—

Estimation of Volatile Acids.

REAGENTS.

Solution of Caustic Soda. 1. 100 grams of NaOH dissolved in 100 c.c. of pure water. The caustic soda should be as free as possible from carbonates and be preserved from contact with the air.

2. Alcohol, of about 95 per cent., redistilled with caustic soda.

3. Solution of sulphuric acid containing 25 c.c. of strongest H_2SO_4 in 1000 c.c. of water.

4. An accurately standardized approximately decinormal solution of barium hydrate.

5. Alcoholic solution of phenol-phthalein.

APPARATUS.

1. Saponification flasks of hard, well annealed glass, capable of resisting the tension of alcohol vapor at 100° C. Each flask should have from 250 to 300 c.c. capacity. Instead of such a flask, an Erlenmeyer flask of the same capacity fitted with a long glass tube or reflux condenser may be used.

2. A pipette graduated to deliver to 40 c.c.

3. Distilling apparatus.

4. An accurately calibrated burette reading to tenths of a cubic centimeter.

Weighing the Fat. The butter or fat to be examined should be melted and kept in a dry, warm place at about 60° C. for two or three hours, until the moisture and curd have entirely settled out. The clean supernatant fat is poured off and filtered through a dry filter paper in a jacketed funnel containing boiling water, to remove all foreign matter and any traces of moisture. Should the filtered fat in a fused state not be perfectly clear, the treatment above mentioned must be repeated.

The saponification flasks are prepared by having them thoroughly washed with water, alcohol, and ether, wiped perfectly dry on the outside, and heated for one hour to 100° C. The flasks should then be placed in a tray by the side of the balance and covered with a silk handkerchief within fifteen or twenty minutes of the time they are weighed. The weight of each flask is determined accurately, using a flask for a counterpoise, or dispensing with the same, as may be convenient. The weight of the flask having been accurately determined, they are charged with the melted fat in the following way:—

A pipette with a long stem marked to deliver 5.75 c.c. is warmed to a temperature of about 50° C. The fat, having been poured back and forth once or twice into a dry beaker in order to thoroughly mix it, is taken up in a pipette, the nozzle of the pipette carried to near the bottom of the flask, having been previously wiped to remove any adhering fat. The 5.75 c.c. of fat are allowed to flow into the flask, and the pipette is removed. After the flasks have been charged in this way, they should be re-covered with the silk handkerchief and allowed to stand fifteen or twenty minutes, when they are again weighed.*

Saponification. 10 c.c. of 95 per cent. alcohol redistilled from caustic soda are added to the fat in the flask, and then 2 c.c. of the concentrated soda solution; a soft cork stopper is now inserted in the flask and tied down with a piece of twine. The saponification is then completed by placing the flask upon the

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* Before weighing the flasks any desiccating material used in the balance should be removed. If round bottom flasks are employed, a special form of holder must be used. This is made on the principle of a test-tube rack, the lower board of the tray being perforated so as to receive the round bottom of the flask, and being protected by lugs, so that on being placed on the table the bottoms of the flasks do not touch the table.

EXAMPLE.

	Grams.
Weight of counterpoised flask No. 3, ...	22.5904
Weight of counterpoised flask No. 3 + fat, ...	27.6734
Weight of fat, ...	5.0830

water or steam bath. The flask during the saponification, which should last one hour, should be gently rotated from time to time, being careful not to project the soap for any distance up the side of the flask. At the end of an hour, the flask, after having been cooled to near the room temperature, is opened.

Removal of Alcohol. The stoppers having been laid loosely in the mouth of the flask, the alcohol is removed by dipping the flask into a steam bath. The steam should cover the whole of the flask except the neck. After the alcohol is nearly removed, frothing may be noticed in the soap, and to avoid any loss from this cause, or any creeping of the soap up the sides of the flask, it should be removed from the bath and shaken to and fro until the frothing disappears. The last traces of alcohol vapor should be removed from the flask by waving it briskly, mouth down, to and fro. Complete removal of the alcohol with the precautions above noted should take about forty-five minutes.

Dissolving the Soap. After the removal of the alcohol the soap should be dissolved by adding 100 c.c. of recently boiled distilled water, warming on the steam bath with occasional shaking, until solution of the soap is complete.

Setting Free of Fatty Acids. When the soap-solution has cooled to about 60 or 70° C. the fatty acids are separated by adding 40 c.c. of the dilute sulphuric acid solution mentioned above.

Melting the Fatty Acid Emulsion. The flask should now be re-stoppered as in the first instance, and the fatty acid emulsion melted by placing the flask on the steam bath. According to the nature of the fat examined, the time required for the fusion of the fatty acid emulsion may vary from a few minutes to several hours.

Distillation. After the fatty acids are completely melted, which can be determined by their forming a transparent oily layer on the surface of the water, the flask is cooled to the room temperature, and a few pieces of pumice stone added. The pumice stone is prepared by throwing it, at a white heat, into distilled water, and keeping it under the water until used. The flask is now connected with a condenser, slowly heated with a naked flame until ebullition begins, and then the distillation continued by regulating the flame in such a way as to collect

110 c.c. of the distillate in, as nearly as possible, thirty minutes. The distillate should be received into a flask accurately graduated at 110 c.c.

Titration of Volatile Acids. The 110 c.c. of distillate, after a thorough mixing, is filtered through perfectly dry filter paper, and collected in a flask graduated at 100 c.c. The 100 c.c. of the filtered distillate is poured into a beaker holding from 200 to 250 c.c., 0.5 c.c. phenol-phthalein solution added, and a decinormal barium hydrate run in until a red color is produced. The contents of the beaker are then returned to the measuring flask to remove any acid remaining therein, poured again into the beaker, and the titration continued until the red color produced remains apparently unchanged for two or three minutes.

Alternate Method of Determining Volatile Acids. Saponification Without the Use of Alcohol. To avoid the danger of loss from the formation of ethers and the trouble of removing the alcohol after saponification, the fat may be saponified with a solution of caustic potash in a closed flask without alcohol. The operation is carried on exactly as indicated above for saponification in a closed flask, using caustic potash solution instead of soda, and omitting the operation for volatilizing the alcohol. The caustic potash is prepared as follows: Dissolve 100 grs. of the purest potassium hydrate in 58 grs. of hot distilled water. Allow to cool in a stoppered vessel, decant the clear caustic solution, which is poured on the fat after it has solidified in the flask. Great care must be taken that none of the fat is allowed to rise on the sides of the saponifying flask to a point where it cannot be reached by an alkali. During the process of saponification, the flask can only be very gently rotated, in order to avoid the difficulty mentioned. This process is not recommended in any except a closed flask with round bottom. In the subsequent solution of the soap, use only 80 c.c. of distilled water, and in setting free the fatty acids, use 60 c.c. of the dilute sulphuric acid. In other respects the distillation is conducted as described. Potash is used instead of soda, so as to form a softer soap and thus allow a more perfect saponification.

The saponification may also be conducted as follows: The alkali and fat in the melted state are shaken vigorously in the saponification flask until a complete emulsion is secured. The rest of the operation is then conducted as above.

Leffmann and Beam recommend the following for saponification:—

The saponification is effected by a mixture prepared by adding 25 c.c. of a clear 50 per cent. solution of sodium hydroxid to 125 c.c. of pure glycerol, *e.g.*, Merck's redistilled, and boiling from 15 to 20 minutes, to evaporate the greater portion of the water.

About five grams of the clear fat are weighed out in a flask in the usual manner, 10 c.c. of the alkali-glycerol added, and the flask heated over a Bunsen burner. The mixture may foam somewhat; this may be controlled and the operation hastened by shaking the flask. When all the water has been driven off, the mixture will cease to boil, and if the heat and agitation be continued for a few moments complete saponification will be effected, the mixture becoming perfectly clear. The whole operation, exclusive of weighing the fat, will require less than five minutes. The flask is then withdrawn from the heat, and the soap dissolved in 90 c.c. of water. The first portions of the water should be added drop by drop, and the flask shaken between each addition in order to avoid foaming. When the soap is dissolved, 50 c.c. of diluted sulphuric acid—25 c.c. of the concentrated acid to the liter—are added, a piece of pumice stone dropped in, and the distillation conducted as usual until 100 c.c. of distillate are collected.

Blank experiments have given a distillate requiring from 0.2 to 0.3 of decinormal alkali.

For the identification of "straight oleos" Leffmann and Beam have found it sufficient to measure out carefully 3 c.c. of the clear, melted fat, and use one-half the quantity of the reagents.

The alkali-glycerol is quite viscid when cold. It should be kept in a flask closed with a rubber stopper and heated when the measured portion is to be taken.

The amount of decinormal alkali necessary for neutralization will be 20 c.c. or over for each five grms. of butter. No other fat contains anything like the percentage of volatile acids. The amount of adulteration or the presence of this fat will be suspected where the quantity of decinormal solution is between 10 and 20 c. c.; where the quantity required is below 10 c. c. there can be but a slight suspicion of the presence of butter. Of the following fats the appended quantities of decinormal solution required for titration shows how small is the amount of volatile acids present in each five grams:—

Lard,	0.4
Rape oil,	0.5
Kidney fat,	0.5
Olive oil,	0.6
Sesame oil,	0.7
Oleomargarine,	1.4 to 2.6
Cocoanut oil,	7.4

Cheese. Cheese is prepared from milk by the coagulation of casein. It may be made from skimmed milk, partly skimmed milk, milk containing a normal percentage of cream, and occasionally, though rarely, from milk containing an excess of cream. Good cheese is rich in nutritive properties. When digestible an abundance of nitrogenous and carbonaceous material may be obtained from a relatively small quantity. Parkes states that about one-half pound contains as much nitrogenous substance as one pound of meat, and one-third of a pound as much fat as a pound of meat. The composition of cheese as given by Yeo from a proximate analysis is as follows:—

Water,	36.8
Albuminates,	33.5
Fats,	24.3
Salts,	5 4

Quality and Adulteration. It is presumed that the quality of cheese can be estimated by the taste; this is not, however, probable. Decomposition may be recognized by the odor and not infrequently by the parasites present. Among the fungi which will be found present in cheese are the aspergillus glaucus and other forms of aspergillus, also the sporendonema casei or red mold. The acarus domesticus, or cheese mite, is the only animal parasite which commonly inhabits decomposing cheese. Occasionally preservatives are applied to the surface of the cheese, and it is stated that copper and arsenious acids are applied to preserve the rind. It is not, however, believed that such applications are common. They may be detected by the ordinary chemical methods. Tyrotoxicon has been found in cheese and probably represents past decomposition, either in the milk or casein, or in the cheese during the ripening process. Statement is made that cheese is sometimes prepared from oleomargarin and lard, but it is not probable that such is ever the case. Cheese may be adulterated by starch, the test for which is iodin.

Eggs. The egg of the ordinary barn-yard fowl weighs from six to eight hundred grains with a mean average near the latter. The eggs of the duck and goose weigh from two to four times as much as the hen's egg. For every hundred grains that an egg weighs, Parkes estimates that 10 grains will be shell, 67.2 water, 22.8 albuminate and fat. Yeo quotes Landois as giving the following for the comparative analysis of the white and yolk :—

	White of Egg.	*Yolk of Egg.*
Water,	84.8	51.5
Albuminates,	12.0	15.0
Fats, etc.,	2.0	30.0
Mineral matter,	1.2	1.4
Pigment extractives,	...	2.1

An approximate calculation of solids may be made by considering each ounce, gross, as representing 100 grains of solids.

Raw and lightly cooked eggs digest with but little difficulty, while the dense and harder cooked yield slowly to the digestive juices. It has been said that there are " more than five hundred ways " in which eggs may be prepared as food.

The preservation of eggs is accomplished by excluding air, which normally may penetrate the porous shell. They may be packed in sawdust or salt, or given a light coating of some impermeable wax or gum, as beeswax in warm olive oil, ⅓ of the former to ⅔ of the latter. Eggs may be pickled by boiling hard, removing the shell, and covering with vinegar.

In selecting eggs, the shell should be clean, that is, not discolored ; no sound should be produced by shaking ; the egg should be transparent, more particularly at the center ; the transparency can best be judged by placing a candle behind the egg ; if one ounce of salt be dissolved in ten of water, good eggs will sink, poor ones float, while eggs advanced in decomposition will float in pure water.

Meat. The advantages of meat as a food are manifold, its comparative cheapness, the large proportion of carbon and nitrogen which it contains, and the fact that man is largely, though not exclusively, a carnivorous animal. Aside from the two essential elements, carbon and nitrogen, we have meat-supplying organic compounds demanded by the organisms for the maintenance of nutrition ; to these we have added an abundance of inorganic salts and a varying quantity of water. The objections to meat lie mostly in the fact that the proper proportion of carbon and nitrogen is not maintained in an exclusive meat diet. Meat affords three parts of carbon to one of nitrogen, and therefore gives us an oversupply of nitrogenous material ; hence the exclusive use of meat as a diet undoubtedly leads to the development of morbid conditions, usually associated with the faulty metabolism of the nitrogenous compounds, and hence the best results are to be obtained by combining the excess of carbon in vegetable products with the high percentage of nitrogen in animal diet. This gives a happy medium in which we reach approximately the relative quantities, 15 of carbon to 1 of nitrogen. Another disadvantage in depending exclusively upon a meat diet—indeed, a disadvantage to be considered at all times—is the liability to the transmission of disease direct from the animal to man. This is no longer a matter for discussion ; scientific and authoritative evidence has accumulated to prove beyond the possibility of a doubt that innumerable diseases may be communicated to man through the medium of meat.

The forms in which meat may be used are fresh or preserved, raw or cooked. Fresh meat is to be commended as superior to any form of preserved meat, and cooked meat is always to be preferred. The eating of raw meat invariably leads, sooner or later, to the development of some form of transmissible disease. Aside from the dangers arising from improper, faulty, or no cooking, we have the fact that the method of cooking alters more or less the digestibility of the food. Thus Beaumont has pointed out that raw pork will digest in three hours, boiled pork in four and one-half hours, and roasted pork in five and one-half hours.

Approximately all meats afford a very closely relative composition, modified more or less by the fatness of the animal from which meat is selected, as will be shown in the following tables.

Beef consists of the meat from cattle, and the composition as given by Yeo is:—

	Lean Beef.	*Fat Beef.*
Nitrogenous matter,	19.3	14.8
Fat,	3.6	29.4
Salines,	5.1	4.4
Water,	72.7	51.0

Veal consists of the meat of the calf. It is more difficult of digestion than beef, although it contains less fibrous tissue and fatty matter. The age is a most important matter. The best veal is from six to ten weeks of age, although it may be used for food as early as the third week; prior to that time it is known as " monkey " veal, and in many cities its sale is prohibited by law or Board of Health regulations.

The composition of veal as given by Yeo is:—

	Water.	*Nitrogenous Matter.*	*Fat.*
Lean veal,	78.82	19.76	0.82
Fat veal,	72.31	18.88	7.41
Loin,	76.25	15.12	7.12
Ribs,	72.66	20.57	5.12
Shoulder,	76.57	18.10	3.62
Leg,	70.30	18.87	9.25

Mutton is the flesh of the sheep; it is rich in fat, is easily digested, and readily assimilated. The proximate food principles as found in mutton are:—

	Water.	*Albuminates.*	*Fat.*
Moderately fat,	75.99	18.11	5.77
Very fat,	47.91	14.80	36.39
Hind quarter,	41.97	14.39	43.47
Breast,	41.39	15.45	42.07
Shoulder,	60.38	14.57	23.62

Pork consists of the meat of the hog. It is proportionately richer in fats and poorer in albuminates than either mutton, veal, or beef. It is, hence, more generously used as a diet by the working class, partly by reason of its relative cheapness but largely on account of the readiness with which it is cooked with vegetables, affording an ideal mixed diet. The composition as given by Yeo is as follows:—

	Fat.	*Lean.*
Water,	47.40	72.40
Albuminates,	14.54	19.91
Fat,	37.34	6.81

Meat Inspection. In consequence of the large amount of meat consumed, the health of the public is more or less influenced by the character of the supply. It is therefore desirable that the meat offered for sale should be of such a quality as to preclude injurious effects to the consumer.

There have been many cases of poisoning, often in an epidemic form, directly attributable to the consumption of diseased meat. As a hygienic measure and with a view to prevent future occurrences of such outbreaks, our legislators have enacted laws prohibiting the sale, for food, of such meat as may deleteriously affect health ; and they have provided that there shall be appointed, by the Government, men whose duty it is to inspect meat and enforce the requirements of law. In Europe, and especially in Berlin, meats are subjected to the closest scrutiny, but in this country the corps of inspectors is not sufficiently large to permit a thorough examination of all the meats exposed for sale in our markets. Many unscrupulous individuals, in their wild endeavors to accumulate wealth, taking advantage of the fewness of inspectors, do not hesitate to sell meats prohibited by law, if it is thought that they can possibly avoid detection.

Meat should be inspected either just before or shortly after slaughtering.

Inspection of the Living Animal. The living animal should be inspected within twenty-four hours preceding the killing, and the inspector should see that the animal is, 1st, *well grown ;* 2d, *well nourished ;* 3d, *that it is of proper age*, and 4th, *that it has the appearance of health.*

Size and Weight. An ox should weigh not less than 550 lbs. av. ; the mean weight about 770 lbs. av.

A cow should weigh not less than 500 lbs. av. ; the mean weight about 730 lbs. av.

A heifer should weigh not less than 300 lbs. av. ; the mean weight about 360 lbs. av.

A full-grown sheep will usually weigh from 60 lbs. to 90 lbs.

A full-grown pig will usually weigh from 100 lbs. to 200 lbs.

To determine the weight of cattle, Notter recommends "to measure the trunk just in front of the scapulæ to the root of the tail and the girth or circumference just behind the scapulæ ;

then multiply the square of girth by 0.08 and the product by the length, the dimensions in cubic feet are obtained; each cubic foot is supposed to weigh 42 lbs. avoirdupois. The formula is $(C^2 \times .08) \times L \times 42$; or $\frac{2}{3} (C^2 \times 5L)$. The result in either case gives the weight in lbs. avoirdupois. In very fat cattle the weight may be 5 per cent. more, and in very lean 5 per cent. less than actual weight found by this rule."

Age. Cattle should be from three to eight years old. The age is determined by examination of the teeth.

Temporary teeth :—

At birth, temporary teeth partially through.

At 20 days, temporary incisors all through.

At 30 days, temporary molars all through.

At 6 months, temporary teeth are grown large enough to touch each other.

At 20 months, temporary incisors, central pair, fall out and permanent appear.

At 27 months, temporary incisors, second pair, fall out and permanent appear.

At 30 months, temporary molars, first and second pair, fall and permanent appear.

At 30 months to three years, temporary molars, third pair, fall and permanent appear.

At 33 months to 3 years, temporary incisors, third and fourth pair, fall and permanent appear.

At 5 to 6 years, development completed and border of incisors little below grinders.

At 6 years, first grinders begin to wear and are level with the incisors.

At 8 years, the wear of the first grinders is very apparent.

At 10 years, used surface of the teeth bear a square mark, surrounded by a white line.

At 12 years, used surface of teeth bear a square mark more pronounced.

At 12 to 14 years, this mark becoming rounded.

The rings on the horns are sometimes taken as a guide to determine the age, but they are very unreliable.

In sheep :—

At 1 week, temporary teeth begin to appear.

At 3 months, fill the mouth.

At 15 to 18 months, fall.

At 3 months, first permanent grinders appear.

At 20 to 27 months, fifth permanent grinders appear.

As a rule, two broad teeth appear every year.

Sheep should always have clean, even teeth.

The age of a pig cannot be told after three years.

Temporary teeth complete at 3 to 4 months.

Premolars appear at 6 months.

Tusks and post-incisors appear at 6 to 10 months.

Remaining post-incisors at 1 to 2 years.

Four permanent molars appear at 6 months.

Five permanent molars appear at 10 months.

Six permanent molars appear at 18 months.

Nourishment. A certain quantity of fat is a requisite in well-conditioned animals. The presence and quality of the fat may best be discovered over the false ribs or ischial tuberosities and over the rectus abdominalis. The flesh should feel firm and elastic and the skin supple.

Health. Health is evinced by the ease of movement, a quick, bright eye; the nasal mucous membrane should be red and moist, the tongue not protruded, respiration regular and easy, the expired air without odor, excreta natural in appearance.

The diseases to guard against are:—

Cattle:—

1. Epidemic pleuro-pneumonia.
2. Foot-and-mouth disease (murrain, aphtha, eczema, epizoötica).
3. Cattle plague (typhus contagiosus, steppedis, rinderpest).
4. Anthrax.
5. Tuberculosis.
6. Actinomycosis.
7. Texas fever.
8. Dropsical affections.
9. Indigestion.

Sheep:—

In addition to the above, sheep should be inspected for—

1. Braxy.
2. Variola ovina.

3. Black quarter (Erysipelas carbunculosis).
4. Phthisis (Strongylus filaria).
5. Fluke disease (Distoma hepaticum).
6. Gid, sturdy or turnsick (Cænurus cerebralis).

Swine:—

1. Anthrax.
2. Hog cholera.
3. Measles (Cysticercus cellulosæ).
4. Trichiniasis.

Epidemic Pleuro-pneumonia. This is an acute contagious, disease primarily affecting the lungs of cattle. It is due to a specific poison, probably an organism. The incubation period is from one to two months. The appearance of the animal is striking; there is a discharge of viscid froth from the mouth and the nostrils, the eyes are dull and sunken, the horns cold, the coat rough, and the animal is unable to stand long.

With the exception of a slight cough, which manifests itself in the incipiency of this dread disease, no diagnostic symptoms are obvious. The animal eats heartily and digests its food; it is lively, and in the cow the milk supply is undiminished.

The first symptoms to evince the presence of this disease are fever, horripilation, and the increased cough. The breathing becomes labored and the expired air has a horribly foul odor; the pulse quickens; the animal moans pitifully; prostration is marked, the animal being compelled from sheer exhaustion to frequently lie down; the appetite fails; rumination ceases; diarrhea is a frequent but not constant symptom, and when it exists the stools are particularly offensive; the tongue is hot and dry. The beast dies from exhaustion, induced probably by a septic toxemia.

The autopsy reveals evidence to sustain the assertion that the lungs and pleura are the original seats of this affection and that the intestines are secondarily involved. The lungs are often gangrenous and sometimes contain abscesses; the vesicles may be filled with a sero-purulent material. These represent not distinct and separate, but different degrees of the same pathological process. The pleura is inflamed, there are adhesions, and it is often gangrenous. When the alimentary canal is affected, the first, second, and especially the third stomachs are inflamed and gangrenous. The food is usually hard and unaffected by the digestive fluids; it is sometimes found putrescent. The fourth stomach is frequently similarly affected, but the food is not hard or putrefying. This disease terminates fatally, and no satisfactory treatment has as yet been instituted.

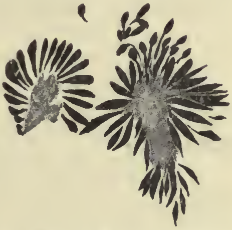
Foot and Mouth Disease. Foot and Mouth Disease is a highly contagious affection, due to a specific cause, as yet undetermined, but probably microbic. As its name implies, it attacks the feet and mouth. In cows the udder is frequently affected. It is characterized by a vesicular eruption on the mucous membranes and those parts covered by delicate skin, elevation of temperature, and a definite course. This disease usually terminates in recovery.

No authenticated cases have occurred in this country, although among the animals shipped to Great Britain in 1880 were twenty-one cattle and sixty-three sheep suffering with this disease. As foot and mouth disease is highly contagious and an epidemic is possible, inspectors should ever be on the alert to detect it and institute such precautions as will prevent its spread.

Typhus Contagiosus. This is a contagious disease produced by a specific poison undoubtedly microbic. An epidemic of the disease is favored by uncleanliness, crowding the beasts in small and badly ventilated apartments, bad food, and inclement and especially variable weather. The incubation period is from six to twelve days.

From the very beginning of the disease the animal is listless. It does not browse with the usual avidity, but wanders about in a dull and stupid manner; it does not stand long, lying down frequently and for a long time; the thirst is intense, appetite is lost, and rumination, if not completely, almost, ceases; the functions of the emunctories are suspended; secretions are dried up; the special senses become obtuse; the animal in some instances becomes wild and furious; spasmodic contraction of the facial muscles sometimes occurs; sensibility is greatly increased along the spine; respiration may be greatly embarrassed and is evidently painful. The tongue and buccal mucous membrane may be inflamed and livid streaks are to be observed, which often ulcerate; this inflammatory process may occur in any portion of the alimentary canal. Later in the disease, from the eyes, which are tumefied and swollen, is exuded a thin fluid which produces an intense irritation of the tissues with which it comes in contact. A discharge from the nostrils and mouth also occurs, diarrhea follows the constipation, and there is an insatiable thirst. The subcutaneous cellular tissue is filled with gas and under pressure crepitates. If the animal does not succumb in the earlier stages, it becomes a living mass of purulent matter and finally dies of septic toxemia.

Fig. 43.



Actinomyces (Ray Fungus) × 800 diam. From bovine actinomycosis.

Actinomycosis. Actinomyces, or ray fungus, is the exciting cause of this disease. The disease belongs to the infective granulomata. The manner of extension and its destructive nature led many to regard it as a malignant growth, either carcinomatous or sarcomatous. As the tongue, which is usually involved, becomes indurated, the Germans have designated the disease "wooden tongue;" in this country it is known as "big" or "lumpy jaw," from the enlargement which ensues when the jaw is implicated. The dorsum of the tongue, the lower jaw, and pharynx are the organs most frequently affected. The fungus is usually introduced with food, such as rye and barley. Ingress of the mature organism into the tissues can only take place when there exists a solution of continuity on the surface of the skin or mucous membranes. The formation of nodules is characteristic of the disease; they are about ¼ of an inch long and ⅛ of an inch wide, slightly elevated and flattened. The epithelium of the mucous membrane covering the nodule degenerates, desquamates, and ultimately, in these situations, ulcers are formed. When the organism localizes in the tissues it first induces inflammation, then cellular hyperplasia. The inflammation pursues a very chronic course, progressing steadily, destroying all structures, excepting none, that may be in its path. First, about the seat of irritation appear numerous small, round cells which infiltrate in all directions, following this, proliferation of the fixed cellular elements ensues. About the fungus and in the center of the nucleus of round cells are developed epithelioid and giant cells. Extension of the disease locally takes place along the connective tissue spaces. Dissemination of the disease is induced by the entrance of the organism, its bulbous ends or spores, into the circulation through defects in the walls of the blood-vessels, and its arrest in distant capillaries, where it establishes independent centers of infection.

Pus is the result of mixed or secondary infection with pus microbes. Suppuration leads to a more active inflammation and diffusion of the infective material. The minute anatomy of actinomycosis so closely resembles that of sarcoma and tuberculosis as to render an absolute diagnosis impossible unless we discover the ray fungus.

The symptoms of actinomycosis are very indefinite, depending altogether upon the organ or organs involved and the supervention of the metastasis and secondary infection.

If the tongue or jaw is the seat of the disease, the course of the affection is very slow, and in the early stages no definite symptoms are manifest. As the disease progresses, the condition of the tongue or jaw interferes with the feeding, and insalivation and mastication are but imperfectly performed. Indigestion and faulty assimilation are sequences of imperfect insalivation and mastication. Emaciation begins with the occurrence of digestive disturbances, and though so slight at first, and so slow in its progress as not to be manifest until the disease is quite advanced, yet, if the animal lives, it becomes extreme. In these cases, salivation is one of the first as well as the most pronounced symptom, and the authors have seen the saliva flow for several hours in a slow though constant stream from animals suffering with "wooden tongue." If the liver or any other appendage of the digestive track is the seat of actinomycosis, its functions are quickly abolished, and digestive disturbances become early and marked symptoms.

Should secondary infection occur the course of the malady will be more rapid; the thermometer will generally show a slight rise of temperature with decided, though irregular, daily exacerbations, and remissions which occasionally fall below the normal. An insatiable thirst, great weakness, drooping of the head, horripilation, and diarrhea are symptoms, one or all of which shortly follow the occurrence of secondary infection by pyogenic organisms, and their severity depends upon the importance of the structures involved and the intensity and extent of the suppurative process.

Metastasis augments the symptoms and hastens the advance of the disease. If the animal is not killed involvement of the mediastinal glands, to be shortly followed by death, almost invariably ensues.

Anthrax (synonyms, charbon, melzbrand) occurs in cattle, sheep, and pigs.

Anthrax is due to a germ, the bacillus anthracis. The incubation period is from twenty-four hours to four days.

This disease manifests itself in three forms: (1) *acute;* (2) *subacute;* (3) *exanthematous.*

The *acute* is also known as the *apoplectic* and is the most rapidly fatal form. Its duration after the period of incubation is from a few minutes to several hours. The animal, apparently healthy one moment, the next may fall suddenly in a convulsion, which death quickly terminates. If the acute is prolonged it passes into the *subacute,* in which the animal loses its appetite, secretions are arrested, trembling and horripilation set in, followed by fever. The circulation becomes accelerated and the breathing difficult and oppressive. Tonic and clonic spasms, exhaustion and dilatation of the pupil, are later manifestations. Diarrheal discharges streaked with blood, are of frequent occurrence. In the *exanthematous* or carbuncular form, in addition to any or all of the above phenomena, we have the formation of carbuncles and erysipelatous rashes, which are tumefied and painful, and subsequently the seat of ulceration.

Post-mortem. Rigor mortis is moderate, the abdominal parietes distended with gas. In the pleural and abdominal cavities are sero-hemorrhagic exudations. Petechiæ and ecchymoses are seen in the pleura, pericardium, endocardium, omentum, mesentery, and intestinal walls. The lungs contain dark, degenerated, grumous blood in large amounts. The heart is flabby and pale, except in situations of hemorrhagic transudation where the tissues are stained a deep red by the escaped coloring matter of the disintegrated blood. The liver, kidney, and spleen are enlarged, softened, granular, and very friable. The excessive enlargement of the spleen is most noticeable and is a constant occurrence. Considerable areas in these organs are infiltrated with sero-hemorrhagic transudations. In the intestines small ulcers are not uncommon. The mucous membranes lining the intestinal and respiratory tracts present evidence of inflammatory processes. The minute pathological changes indicate that the bacillus anthracis incites in the tissues a non-suppurating inflammation. The blood-vessels contain such vast numbers of organisms that the circulation is so impeded as to induce ischemia. The bacilli are found in greatest numbers in the vascular viscera (liver, kidney, spleen) and where the blood current is slowest. The capillaries are enormously distended by the accumulation of blood and the presence of bacilli. The integrity of their walls is often destroyed and rhexis occurs. Local edema is the result of the lumen of a blood-vessel becoming obstructed by the aggregation of numberless bacilli, causing transudation, emigration, and diapedesis; thus the paravascular and connective tissue spaces become crowded with leucocytes, preventing reabsorption of the serum, increasing the extravascular pressure, and thus enhancing the obstruction to the circulation.

The red blood cells undergo a degenerative process and many are destroyed by the bacilli. Leucocytosis sometimes exists, but it is relative rather than absolute.

Prognosis. From 60 to 70 per cent. die, probably from the action of specific bacterial products upon the respiratory center.

To insure destruction of the contagion, all animals dying of anthrax should be burned.

Anthracoid Diseases. *Emphysema Infectiosum* and *Texas Fever.*

Emphysema Infectiosum, or black quarter, is an acute infectious malady, due to a small and thin motile bacillus. This bacillus has been demonstrated at the site of the local lesion and in the blood. An intravenous injection of fluid containing this bacillus is innocuous, the serum or phagocytes destroying it, but if an injury is inflicted severe enough to produce extravasation, the organism localizes at this *locus minoris resistencia* and exerts its specific action. Death usually follows in a few hours the appearance of the initial symptoms, and may be attributable to

Fig. 44.

Symptomatic Anthrax.
Emphysema infectiosum.

the absorption of toxines. Other than the local effects of the injected organism, no lesions are to be detected when the animal dies in the early stages. If the animal does not quickly succumb, gangrene of the affected part supervenes. An enormous quantity of gas is generated in the tissues, giving rise to a marked emphysema. When the skin is stroked or an incision made into the tissues, crepitation is noted, and hence the term *Rauchbrand*, which is also applied to this affection.

After death rigor mortis sets in early and is usually quite pronounced, the blood is dark, grumous, and not coagulated, although occasionally ante-mortem thrombi are found; extravasations are met with in many parts of the carcass and the tissues are generally deeply stained. Infiltration of the subcutaneous and connective tissues by a yellow gelatinous material often happens. The lymphatic glands are enlarged and injected and more or less stained by disintegrated blood. The abdominal and thoracic cavities contain bloody exudations. The pleura and omentum are injected and petechial spots are sometimes found.

The mucous membranes are injected, and throughout the alimentary canal numerous ecchymotic spots occur; the epithelium degenerates and in many places desquamates. A characteristic odor emanates from all parts of the carcass.

Texas Fever. There exists a striking analogy between the Texas fever of cattle and the yellow fever of man. The conditions under which these diseases exist, and which favor their development, which limit or arrest their progress or destroy them, are identical. The similarity between the maladies is maintained in the course which they pursue. Hence we might infer that the same cause is acting in each of these diseases. Sternberg asserts that yellow fever is engendered by a microorganism which has not as yet been identified, but which he claims to be in a fair way of discovering. The poison, whatever it may be, is confined to certain districts, or rather we should say that its life and virulence is dependent upon certain definite and well-defined climatic conditions. Warm, moist climates are particularly adapted for the development of the poison, while frost destroys it. The influence of cold is well seen in Texas, where, during a prevailing or severe epidemic, if cold east winds or one of their famous "Northers" set in, the severity of the disease is greatly mitigated, or it may be completely checked and disappear.

Billings advocates dividing the disease into three stages: first, *Stadium incubations* or the period of incubation; second, *Stadium accrementi*, or a period of activity, or progressive stage; third, *Stadium decrementi*, or period of decline. The incubation period is from 20 to 30 to 40 days. The disease is ushered in by a chill, followed by a fever, thirst, perverted secretions, markedly elevated temperature, accelerated pulse, and exhaustion. The attitude of the animal is peculiar and characteristic; the head droops as though the animal was too exhausted to hold it up; the ears fall forward, the hind legs are advanced under the body, thereby causing arching of the spine, and marked depressions appear in the flanks. In many cases hematuria exists and often is the first patent manifestation of the disease. With the progress of the disease the temperature declines and the exhaustion becomes extreme. Apathy and stupor are the precursors of death. The prognosis is very unfavorable, from 30 to 70 per cent. dying.

Recent experiments by Dr. Theobald Smith and F. L. Kilborne, under the direction of Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, seemed to demonstrate that the etiological factor in Texas fever is a peculiar microörganism. In their article the parasites are described as pyriform bodies from 2 to 4 μ in length, and from 1.5 to 2 μ in diameter at the widest portion. These bodies are found principally within the red blood corpuscles, two, usually, occupying one corpuscle. The organisms are disposed, almost invariably, with their tapering end in juxtaposition, though no mutual connection between them could be demonstrated. The authors describe two forms, probably different stages in development of the same organism. The smaller forms are homogenous, while the larger forms contain in the rounded end a small spherical body, which, in contrast with the substance of the parasite is very dark in appearance; though in several cases when examined with very high powers, it manifested a remarkably brilliant appearance. It is estimated that the body is from 0.1 to 0.2 μ in diameter. Oval bodies, somewhat larger than the spherical body just described, were discovered in the large round ends of the largest pyriform bodies. The size of this body is given at from 0 5 to 1 μ. The parasites when examined upon a warm stage exhibit ameboid movement very much resembling that seen in the leucocytes of mammalian blood.

The authors of these investigations deduce from their observations that the ameboid movement only occurs in the younger parasite, and that the conformation of the mature pyriform bodies is fixed and undergoes no change.

The parasite may be stained with Löffler's alkaline methylene blue solution, or by aqueous solutions of methyl violet, or gentian violet. When treated with methylene blue the peripheral portions are stained, while the center remains quite unaffected. The intracellular parasites, in the acute manifestations of the disease, frequently occur as single, irregular bodies, and the paired pyriform bodies are comparatively rare.

Dr. Salmon and his co-laborers attribute to the tick, the important rôle of being the sole infection carrier, and positively state that without the tick an outbreak of the disease is impossible.

The period of incubation, determined by inoculation experiment, is given as six to ten days.

Texas fever exerts its principal and primary effects upon the blood, and the pathological alterations noted in the spleen, liver and kidneys are only secondary processes.

The affected red corpuscles become irregularly notched and creased and are beset with spine-like projections. Their color is usually darker than that of the normal corpuscles.

The destruction of the red blood-corpuscles is the most constant and salient feature of Texas fever, and the above investigators record cases in which the corpuscles disappeared at the rate of from 700,000 to 1,000,000 per cubic millimeter during the last few days of life. These examples were from the severer types of the disease; in the milder form, however, the destruction of the corpuscles was less extensive. The destruction of the corpuscles is, in all cases, directly proportionate to the severity of the attack.

These experiments may prove to be invaluable, but before being accepted as final, should receive the confirmation of other investigators.*

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* This book was in press when we obtained an account of these investigations, and consequently we had not the opportunity to thoroughly review the work.

Post-mortem. The liver is enlarged, soft, friable, and very pale. Upon section it is stained a peculiar yellowish color, the effect probably of the admixture of the blood and bile which escape into the tissues. The gall bladder is distended with a viscid fluid. The spleen is greatly enlarged, in some cases weighing as much as ten pounds. It is degenerating and granular. Kidneys are congested, enlarged, and granular. Abomasus congested and marked by many petechiæ. Small intestines congested and the seat of hemorrhagic and serous transudations. The cecum, colon, and rectum are also the sites of similar processes. The other organs and tissues are described as seemingly normal; this is questionable; they have probably all undergone at least those changes which are the concomitants of continued elevation of temperature.

Tuberculosis. The cause of this scourge is the bacillus tuberculosis. This disease is infectious and presents definite and characteristic symptoms: macroscopical and microscopical lesions.

The order, in frequency, of primary infection of organs is (1) the lymphatic glands; (2) serous membranes of thorax and abdomen; (3) lungs; (4) liver; (5) kidneys; (6) brain. The udders of cows are often the site of tubercular disease and many cases supposed to be garget or weed (simple mammitis) are in reality tuberculosis. The heart, spleen, and general muscular system in cattle is seldom the seat of primary infection.

If the ingesta contain the infecting bacilli, it is the mesenteric glands that first manifest evidence of the disease. If the infection occurs through the skin or mucous membranes, usually it is the nearest, anatomically, situated lymphatic glands that develop the characteristic change before the viscera are at all affected. The glands become tumefied and softened. The afferent vessels are obstructed by the inflammatory products and the access of additional bacilli prevented. If the number of bacilli increase, it is due to the pullulation of those already present.

Tubercles develop on the infected serous membranes, and by confluence form large nodular masses. From the peculiar appearance of these masses they have received many names, each intended to be descriptive; thus in Great Britain they are known as the "grapes" and "angle berries," and in Germany as "duck weed disease" and "pearl disease" (Perlsucht).

Pathology. Lungs. The gross appearance of a lung in fairly well developed cases of phthisis is striking. Considerable areas of tissue contiguous with the tubercular foci frequently present the appearance of intense congestion. The tubercular nodules are opaque, grayish or grayish-yellow in color, and vary in size within wide limits. The smaller tubercles cannot be seen by the unaided eye, though if the hand be passed over a cut surface, they will convey an impression which may be likened to that of grains of sand embedded in the tissues. The larger tubercles are engendered by the confluence of many of these minute foci. In miliary tuberculosis, hyperemia of the mucous membrane of the bronchi is generally to be seen. It begins in the main bronchi and increases in intensity as it proceeds downward into the smaller bronchi. Increase in the production of mucus, which becomes quite adhesive and viscid, is the constant accompaniment of hyperemic bronchi. According to Rindfleisch, localization and pullulation of the bacillus tuberculosis occurs at the junction of the bronchioles and acini. The exceedingly destructive processes engendered and the coalescence of many tubercles cause extensive involvement of the lung structures. The contraction of the surrounding connective tissue upon the blood-vessels and the greatly increased extra-vascular pressure cut off the blood supply to the tubercular mass, which undergoes caseation or a fatty degeneration and the lung tissues within this area, coagulation necrosis. Disintegration and liquefaction of this material supervenes and it is converted into a creamy liquid; the color is, frequently, greenish-yellow. Communication with a bronchus being effected, this puriform material is extruded and there remains at these sites large cavities. It is claimed that bronchiectasis plays an important part in the extension of the disease, and Rindfleisch asserts that dilated bronchi form, in part, the walls of some cavities. There are cavities which do not seem limited by a definite wall, but are environed by softening tubercular and caseous masses and breaking-down lung tissue. Other cavities seem to be lined by a granulation membrane, which exudes a foul smelling, greenish-yellow, puriform material. In recently formed cavities the sides are uneven and ragged, and large bands of lung tissue, bronchi and blood-vessels traverse them in all directions. In miliary tuberculosis both lungs are involved throughout and the progress of the disease is so rapid that the animal succumbs before the above processes develop.

In the other organs primary infection is a rare occurrence, the changes, however, are nearly identical, being modified slightly by the structure of the viscus.

Minute Anatomy of a Tubercle. The deposition of the bacillus tuberculosis in the tissues results in the destruction of the proper tissue elements and in the production of tubercles. The integral parts of a tubercle are, (1) reticulum, containing in its meshes (2) embryonal tissue, consisting of (*a*) leucocytes which have migrated from the blood-vessels of the affected area, and (*b*) epithelioid cells, the progeny of the fixed connective tissue and other cognate elements, such as the endothelial cells of the capillaries and lymphatics. With the progress of the disease, we have developed from the migrated leucocytes lymphoid cells, which at one time were supposed to be pathognomonic, but which we now know to occur in other affections, notably in phthisis of sheep due to the strongylus filaria. Giant cells are formed in the center of the inflammatory foci by the increment of the cell continuing, its nucleus dividing, but the perinuclear protoplasm remaining intact. Caseation begins in the center of the nodule and proceeds toward the periphery. Giant cells often undergo a fibroid metamorphosis which begins at the periphery, and they ultimately form small cicatricial masses.

Epithelioid cells are smaller than the giant cells; they are globose or ovoid, have one large nucleus and many smaller ones, and are very granular. They ultimately degenerate, becoming caseous or undergoing fibroid changes.

Liver. In this organ the tubercular process is both circumscribed and diffused. When circumscribed the nodules appear spherical or ovoid masses, opaque and grayish-yellow or yellowish-green in color, and in other physical characteristics they resemble those found in the lungs. In diffused infection the process commonly extends along the portal vein and its ramifications. It offers greater or less obstruction to the circulation of the liver, depending upon the extent of the process and the pressure exerted upon the vein. The most characteristic feature of tuberculosis of the liver is its peculiar orange-yellow color, due largely to fatty changes.

Meninges. It is in miliary tuberculosis that the meninges of the brain generally become involved. The earliest lesions become patent as grayish-white, translucent, gelatinous bodies disposed along the vessels of the pia mater. New centers of infection are continually forming as the disease progresses, and tubercles in all sizes from the smallest possible visible point to that of a pea may be seen. The intensity of the inflammation does not depend so much upon the number of tubercles as upon the supervention of secondary infection with pyogenic bacteria.

As to the membranes the pia undergoes thickening, becomes opaque and is covered with a gelatinous exudate, while the dura and arachnoid also undergo thickening and form adhesions.

The choroid plexus becomes extremely hyperemic, and effusion to a greater or lesser extent into the ventricles almost invariably occurs. Miliary tubercles may be found in the cortex, which, if the effusion be slight or absent, may also be edematous.

Kidneys are subject to the deposition of tubercles in two forms, disseminated and localized. The disseminated form occurs but rarely, and it consists in the development of gray tubercles throughout the renal parenchyma from tubercle bacilli deposited in the sheath of the vessels. The localized is much oftener met with and consists in the deposition of the tubercular material in the renal papilla by extension from the calyxes and pelvis. With the development of a number of miliary tubercles they become confluent and in the manner previously described form large tubercular nodules. Excavations are formed by these nodules undergoing degenerative processes and subsequent extrusion of the caseous or liquefied elements. The kidney increases in size and becomes nodular; the capsule thickens and gets to be quite indurated, and cheesy deposits may be found upon it. Ultimately the whole of the renal parenchyma is destroyed and nothing remains but the connective tissue, which originally formed the septa of the calyxes.

The course and symptoms of the disease depend upon, 1. Whether the animal is predisposed to the disease by reason of transmitted tissue peculiarities from one or other of the parents.

If this be the case, the animal will possess powers of less resistance to invasion by the bacilli than will the offspring of healthy parents. 2. The site of the disease and the organs involved. 3. The occurrence of secondary infection by pyogenic organisms.

When the lung is primarily affected, usually the first and most pronounced of the early symptoms is a rough, weak cough, which soon becomes associated with difficult respiration. With the progress of the disease, respiration becomes more frequent and shallow. In the acute and subacute cases the frequency of the heart's beat is increased, though diminished in force.

A continuous fever with a marked diurnal exacerbation and remission and emaciation, which, though slight at first, rapidly develops with the progress of the affection, are also characteristics of the acute and subacute varieties. In cases where the course of the disease is slow, there are no febrile manifestations, and generally the emaciation is so slight as to be inappreciable. Perversion of secretions sooner or later develops in all cases, and this results in faulty digestion and assimilation; further, it gives rise to indigestion and diarrhea. Thus does the perversion of secretions indirectly increase the emaciation and weakness. When the intestines and peritoneum become involved diarrhea of the most severe and obstinate form sets in.

In cases where the progress of the affection is rapid the milk is of poor quality, and often the daily yield is much diminished. Tubercle bacilli can always be detected in the milk when the udder is affected with the disease, and, moreover, the bacilli have been found in milk when, after the necropsy, no tubercular lesion could be demonstrated in the organ. However slight may be the lesion, this fact is amply sufficient to condemn, as food, all milk from tubercular animals. Tuberculosis of the udder is usually the result of metastasis and almost invariably points to the general dissemination of the bacilli. Tuberculosis of the udder when not complicated with infection by pyogenic organisms always pursues a chronic course, and so insidious is its progress that were it not for the concomitant symptoms it would never be suspected. In such instances the quantity and quality of the milk will depend upon the constitutional effects of the disease. In the beginning of the disease the yield of milk is undiminished, but if the disease steadily advances, it gradually becomes less and less, until finally it ceases.

Whenever secondary infection supervenes the course of the malady becomes more rapid, wide spreading, and destructive. Cases of purely tubercular infection, excepting miliary and general tuberculosis, are usually extremely chronic, and further it is possible for recovery to take place by the tubercular area undergoing caseation and becoming enclosed by a dense fibrous capsule or by the supervention of calcification. If any animal recovers from what has been diagnosticated tuberculosis, it does not prove the diagnosis incorrect. Animals that recover from a tubercular lesion are extremely liable to subsequent infection. Under no circumstances should any part of the carcasses of tubercular animals be used for food. An attempt should be made to stamp out the disease by killing and incinerating the bodies of all the affected animals.

When the interior of large viscera are involved, *i.e.*, lungs, liver, brain, etc., the symptoms are more pronounced, and the course of the disease more rapid than when the lesions occur externally, *i.e.*, upon the pleura, mesentery, or lymphatics.

Physical Signs. When the lungs are the seat of the disease, deficiency in inspiration on the affected side is an early developed physical sign. The percussion note varies during the course of the disease. Auscultation reveals subcrepitant râles at the end of inspiration, and later in the course of the malady larger moist or mucous râles. The respiratory sounds also undergo changes, inspiration becoming blowing in character and ultimately bronchophonic; with the formation of cavities the breathing becomes amphoric and cavernous. Expiration is prolonged.

It is claimed that a positive diagnosis of tuberculosis can be made by subcutaneous injection of tuberculin; healthful animals offering no reaction to the reagent, while a marked hectic development occurs in tuberculous animals. There are no objections to its use, as it is believed to be innocuous in non-tubercular animals.

Glanders and *farcy* are due to one and the same cause, the *bacillus mallei*, and they differ only in the seat of the pathological lesion. In glanders it is the respiratory tract that is attacked, while in farcy the lesions are in the cutaneous and subcutaneous tissues and in the superficial lymphatic glands.

Glanders is essentially an equine disease, although it may be transmitted to all domestic animals except cattle. Sheep are particularly susceptible to the poison. It occurs occasionally in man as the result of infectious material coming in contact with an abraded surface.

Glanders is highly infectious, and all animals attacked by this disease should be immediately isolated or destroyed, and the stable in which the animal has been kept thoroughly cleaned, disinfected, and vacated for a considerable period.

Glanders may pursue an acute or chronic course. In *acute glanders*, the febrile manifestations are decided, there is an abundant discharge from the nostrils, which may be mucoid or muco-purulent. There is extensive ulceration of the nasal mucous membrane, and tumefaction of the submaxillary, cervical and sublingual glands. The lungs are the seat of an intense inflammation, undergoing the successive changes incident to congestion, effusion, and consolidation. Abscesses form, and small nodules resembling miliary tubercles are disseminated through the lungs.

Chronic glanders is very insidious in its incipiency, and for a considerable period the only manifest symptoms may be a viscid discharge from the nostrils. Later in the progress of the affection we have tumefaction and induration of the submaxillary glands; a cyanotic appearance of the nasal mucous membranes, a development of ulcers, particularly upon the septum. Febrile conditions may not be evinced until late in the malady; emaciation in some cases is inappreciable, in others, pronounced. In the latter case the flesh is pale or may appear dropsical. In the lungs miliary nodules may be detected.

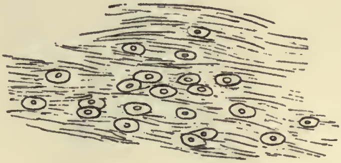
In *farcy* also we have presented the acute and chronic varieties. Acute farcy is distinguished by a high temperature, accelerated pulse, thirst, and arrested secretion, the rapid swelling of one or more of the limbs, and later by the development of "farcy buds," the pathognomonic lesion of the disease. These buds form in the course of the lymphatic vessels, they rupture and discharge a puriform material which is highly infectious. Ulcerations of a very intractable nature ensue after rupture of the buds. The chronic variety is usually without fever, and here, as in the acute form, we have a plastic inflammation in the course of the lymphatics which results in the production of "farcy buttons," swelling of one or more limbs, and tumefaction of the lymphatic glands. The lesions are situated principally in the neck, withers, and back.

"*Hoose*," or the so-called "*phthisis of sheep*," is due to a parasite, of the class Nematoda, the *Strongylus filaria*. Organisms of the same class are found in cattle, the *Strongylus mucrurus*, and in hogs, the *Strongylus paradoxicus*. The malady is usually confined to small, circumscribed areas in one lung, although it may be diffused and both lungs extensively involved. It excites chronic inflammation and causes an effusion of serum into the bronchial tubes and atelectasis. In the incipiency, no marked systematic alterations are recognizable; later there is a marked emaciation and exhaustion.

FIG. 45.

BRAIN OF LAMB, with tracts of Cœnurus. (*After Leuckart.*)

FIG. 46.



MEASLY PORK (½ natural size).

"*Fluke*," or "*Liver Rot*," affects sheep, cattle, and horses; it is occasioned by a flat, oval, leaf-like parasite, which is one inch long and one-half of an inch in the broadest part. (See Fig. 24, page 49.)

The eggs and embryo develop in water, hence we find low, swampy, moist regions and wet seasons peculiarly adapted for the propagation of the organism and conducive to the spread of the malady. The bile ducts, the seat of predilection, are occluded by aggregations of the parasite, organic changes are induced, and the functions of the liver annihilated; as a consequence we have engendered anasarca, jaundice, diarrhea, falling of the hair, extreme exhaustion, and emaciation.

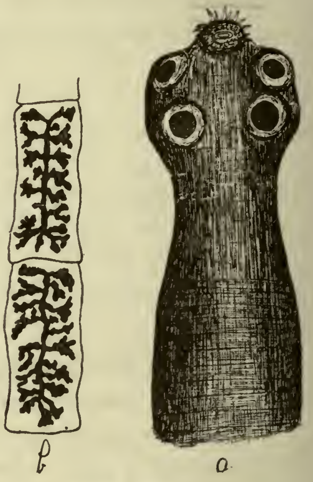
"*Turnsick*," "*Strudy*," or "*Gid*" is an hydatid disease of the brain, or cord, of sheep and oxen. The *Cœnurus cerebralis*, of the class Cestoda, the progeny of the *Tænia cœnurus* of the dog, is the cause of the malady. This disease in its incipiency is very insidious, and no marked structural alterations of the tissues are to be detected. In the later stage the animal rapidly emaciates, becomes anemic, has marked brain symptoms, and there is great depression of the vital powers.

"*Measles of pigs*," or "*Measly Pork*," is caused by the presence of the *Cysticercus cellulosa*, class Cestoda, in the muscles, though between the fibers, of both the striated and non-striated varieties. It is also found in the liver, imparting to it a mottled appearance, in the spleen, brain, connective tissues, and serous membranes. The cysts are about the size of a pea, and may be detected embedded in the tissues; they consist of a capsule containing fluid and the scolex. During life there are no diagnostic symptoms of any value, and the only reliable evidence of the disease is presented by the development, on either side of the inferior and the lateral aspect of the tongue, or between this and the lower jaw, of a chain of small, translucent vesicles. The body has a dropsical and at times cyanotic

Fig. 47.

Cysticercus Cellulosæ.
Completion of head formation. × 12 diam.
(*After Leuckart.*)

Fig. 48.

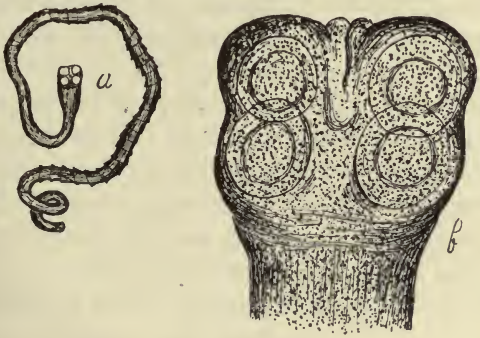


Tænia Solium.
a, head × 40 diam. (*After Leuckart.*) *b*, two segments showing branched uterus.

appearance; to the touch it is flabby, and firm pressure elicits a crackling sensation, due to the rupture of cysts. The Cysticercus cellulosa is the progenitor of the Tænia solium of man.

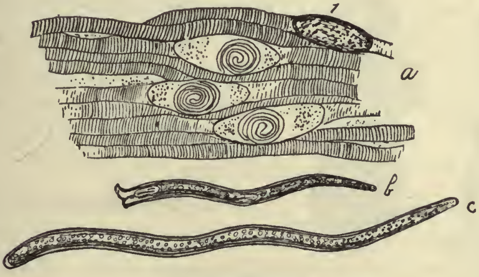
The "*Cysticercus bovis*," "*Measles*" *of cattle*, is the progeny of the Tænia mediocanellata. It is found in greatest abundance in the parietes of the head and muscles of the haunch.

Fig. 49.



Tænia Mediocanellata.
a, Head and immature segments (slightly enlarged). *b*, head × 30 diam.

Fig. 50.



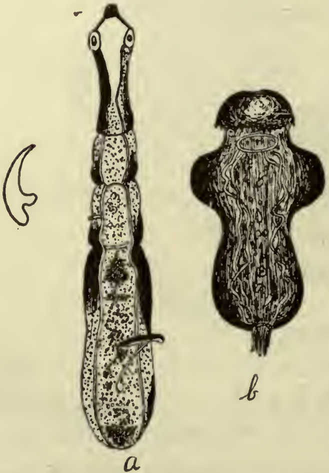
Trichinæ Spiralis.
a, Muscle trichinæ. *b*, Male trichina. *c*, Female trichina. 1. Trichina, showing opaque calcareous capsule. When this stage is reached in man, symptoms disappear and the patient recovers.

The cysticercus bovis is similar to the cysticercus cellulosa, and the observations made regarding the latter are, from a hygienic standpoint, equally applicable to the former.

Trichiniasis is a disease attributable to the *Trichina spiralis*, a worm of the class Nematoda. This parasite is transmitted from the rat to the pig and thence to man by the consumption of infested meat. As occurring in the intestines, they are sexually mature and reproduce young viviparously, rapidly, and in vast numbers. The embryos are exceedingly active and the phenomena of the disease are attributable to their penetration of the intestinal parietes and the subsequent invasion of the muscles, especially the striated. In the muscles the trichinæ become encapsulated in the muscle fiber and may be perceived by the unaided eye as small, white, globose bodies. The capsule of the cyst, which is composed of fibrous and calcareous substances, enables it to withstand high temperatures, 156° F., extreme cold, desiccation, and, after one year, according to M. Fourment, the action of salt. The number of parasites that may inhabit the tissues is amazing; Billings reports a case in which five centigrams of meat contained at least fifty trichinæ. The symptoms of this disease are vague and ill-defined, and no reliable diagnosis can be made without the aid of the microscope. (Technic of examination for trichinæ, chapter on Technic.)

The *Stephanus dentatus* is responsible for a particular form of the disease in pigs known as hog cholera. It is found chiefly in the fat, where it becomes encysted. The cysts are quite large, in some cases being one and three-fourths of an inch long and one-half of an inch in diameter, and contain from three to six eggs. The phenomena of the disease are the result of migrating embryo.

Fig. 51.



Tænia Echinococcus (*After Leuckart*). *a*. Adult Tænia echinococcus. *b*. Head of Echinococcus veterinorum. On the left a detached hooklet.

The *Echinococcus veterinorum*, or the proscolex stage of the Tænia echinococcus, is universally distributed. It has many heads and each one capable of developing into a tapeworm. This parasite infests man, cattle, sheep, swine, and other animals. It is most frequently found in the liver and lungs, and in adults and the aged rather than in the young. The bladderworm consists of a membranous capsule filled with a limpid fluid and the scolex. They are found as simple, endogenous, and exogenous cysts, which may be mistaken for tubercles. Animals affected with echinococcus veterinorum should be destroyed; for, although consumption of this meat may not militate against the health of man, if fed to animals will perpetuate the tapeworm.

"*Braxy*" is an indefinite term applied to diseases of sheep. Many investigations have been made by competent observers, and the results are very conflicting. In certain districts the term braxy is used to designate anthrax, while in other districts it may denote the ordinary septic processes or merely a cachectic state. In passing an opinion on sheep affected with this malady, the inspector will have to rely upon his knowledge of anthrax and septic conditions. How to distinguish these diseases is discussed under cattle diseases and inspection of meats.

Smallpox occurs among sheep in a very virulent form, and infected districts should be placed under the strictest quarantine surveillance. It is exceedingly infectious and is caused by a specific microbic poison. The disease shows the same characteristic eruption and symptoms observed in men.

Meats, Carcasses, etc., to be Condemned. Animals dying from or slaughtered while suffering with parasitic diseases, especially epidemic pleuro-pneumonia, foot and mouth disease, Texas fever, cattle plague, anthrax, tuberculosis, actinomycosis, black quarter, variola ovina, phthisis of sheep (strongylus filaria), fluke disease, gid, hog cholera, measles of pigs, trichiniasis, or general septic conditions should be condemned. If there is no danger from the organism itself, there may be from the toxines which are the result of its physiological activity. The latter fact probably explains why so many cases of poisoning are reported when the meat which constituted the main portion of the meal was apparently healthy. The tissues in the animal parasitic diseases ultimately become wasted and innutritious and are wholly unfit for food. If the inspector has not the power to have the carcass destroyed, he should at least insist on the destruction of the part affected and the contiguous tissues.

Tuberculosis may be transmitted from cattle to man by eating meat or drinking milk containing viable bacilli or spores. The bacilli have been found in the blood, secretions and in the juice expressed from muscles. Localized tuberculosis in cattle is a rare affection. The meat or milk of animals suffering from tuberculosis should never be used for food.

Anthrax, wool sorters' disease, or malignant pustule, is communicated to man from animals by eating the flesh of infected animals or by actual contact with the carcasses or hides. The carcasses should be destroyed, as they are wholly unfit for food.

Black Quarter is communicable to man. It is highly infectious, and all animals suffering with the disease should be condemned and destroyed.

Foot and *Mouth Disease* is infectious. Livt states that in 1834, 1835, and 1839 this disease prevailed among the cattle of Paris and Lyons, and although sold for food no bad results were noted. The affected parts were destroyed.

Cattle Plague. It is asserted by some authorities that the cooked flesh of animals dying or slaughtered while suffering with the disease may be eaten with impunity. The pathological changes in this disease are so pronounced and general that, in our opinion, animals affected with it should be condemned, and the majority of experts do condemn them, as unsuitable for human food.

Epidemic Pleuro-pneumonia and *Texas Fever* are both probably due to a microbic poison. Admitting there is no danger of transmitting the disease to man, the meat contains bacterial products (ptomaïnes) which may give rise to poisoning, therefore it should be destroyed.

Actinomyces may never have been proven to infect man from cattle, still it is possible. It is not always a local disease, and animals affected with it should be rigidly inspected. Man is not endowed with immunity against this organism, therefore meat infected with actinomyces should be unhesitatingly condemned.

Trichinosis occurs in man as the result of eating trichiniferous meat. The action of the digestive fluids destroys the capsules and liberates the parasite, which rapidly matures and multiplies. As the parasite penetrates the entire economy, the carcass should be rejected as a whole.

Inspection of Dead Meat. In many instances it is impossible for the inspector to examine the living animals. On such occasions he should demand the viscera, and cases from which they are not obtainable should excite suspicion and the carcass be subjected to the closest scrutiny. The inspector should endeavor to guard against the tricks practised by some butchers, *e.g.*, introducing a quill into the subcutaneous tissue of poor animals and blowing it full of air, or forcing into it melted fat. The carcasses in such cases exhibit a more or less emphysematous condition. The skewering of the fat of one animal to the carcass of another, and selling it for the first; a procedure known as stripping, that is, removing the pleura when it is affected by disease; and substituting one kind of meat for another, are artifices often perpetrated.

The macroscopic and microscopic appearance of the organs are described under the various diseases. Inspection of dead meat should, when feasible, take place from six to forty-eight hours after slaughtering; and the method of killing, dressing, and the state of the atmosphere, temperature, and humidity be taken into consideration. In eviscerated carcasses special attention should be directed to the condition of the lymphatic glands, connective tissues, skeletal muscles and bone marrow.

Lymphatic Glands. In healthy young and adult animals these glands are of firm consistence, moist, and of a uniform grayish-yellow color, and in anile animals are at times indurated and portions of the periphery pigmented. Congestion, tumefaction, hemorrhagic areas, exudations, and infiltration of the glands indicate disease, and corroborative evidence should be looked for in other parts of the carcass. The regions in which the glands are most readily discovered are—sternal, in the immediate vicinity of the ninth and tenth dorsal vertebræ, the lumbar, and in the deep and superficial inguinal regions.

Connective tissue in health has, after a short exposure to the atmosphere, a glistening appearance and is very moist, though no dripping should occur. In some places it contains considerable quantities of fat, while in others it is quite free from adipose tissue. Occasionally small veins are perceived crossing it, and this imparts to the meat a marble appearance. Connective tissue is found in greatest abundance in the flanks, breast, under the shoulders, above and posterior to the perinephritic fat, along the spine, and immediately subjacent to the diaphragm, and it is in these situations that dropsical effusions accumulate and where we frequently detect evidence of tuberculosis.

Skeletal Muscles. Healthy flesh or muscular tissue presents certain characteristics in different animals, thus, in the adult ox, it has a uniform florid appearance, which in the young ox is lighter, but after the animal has passed its sixth year becomes darker. It exhales a pleasant odor, especially when cooking, has a delectable, sweetish taste; it is firm and elastic, but not tough, its resistance is uniform, and rigor mortis sets in early. The fat ranges from white to straw color except in Jerseys and Guernseys, where it is yellow. The muscular tissue of the horse is darker and coarser than that of an ox, its odor is rather unpleasant, and it has a sweetish, sickening taste. The fat is yellow and softer than that of an ox. The muscular tissue of the calf is pale and lacks the firmness of ox flesh. The fat is also pale and soft. In the fetus and new born calf, " monkey veal," the flesh is watery and has a macerated appearance, and the fat resembles tallow.

Muscular tissue of sheep is a light red color, it deepens with age, and in the old ram and ewe is almost as dark as the flesh of the ox. It is firm and sets early. The fat is white and firm and is evenly distributed over the back and sides of the animal. The fat is not found between the individual muscles to any extent. The odor emanating from the carcass is distinctive.

The muscle of the hog is lighter than that of the sheep, and it is much softer, as is also the fat, which has an unctuous feeling and is deposited in smooth layers around the kidneys and over the back and sides, forming the " panniculus adiposus." The flesh of pigs has a slight though characteristic odor, which in old boars becomes more pronounced.

Pallor of muscular tissues is a concomitant of dropsical conditions, hydremia, indigestion, and choking; in the latter two the muscles are seemingly parboiled and macerated, and are the seat of serous and sero-hemorrhagic transudations.

White flesh is due to the presence of abnormal quantities of adipose tissue, the formation of which is facilitated by conditions engendering diminished oxidation. If it occurs in a small and circumscribed area, it is of no moment, but if general, it indicates grave pathological changes.

Yellow color occurs occasionally in healthy animals, but is usually dependent upon functional diseases of the liver. In the vicinity of the gall bladder the tissues are stained, but this staining is circumscribed. To warrant condemnation it should be associated with other changes which indicate disease.

A magenta hue is observed in the acute stage of some specific affections, such as rinderpest and tuberculosis. Upon section there is an albuminous exudation, which, coagulating upon the exposed surface, imparts to it a glossy appearance.

A scarlet hue is seen in carbonic oxid and arsenical poisoning; reddish brown or black due to imperfect aëration of the blood in organic diseases of the lungs and in mechanical obstructions to the entrance of air into the lungs. It occurs in poisoning by alcohol, chloroform, ether, and turpentine, also in inflammatory affections, drowning, suffocation, and imperfectly bled animals. A mahogany color is caused by faulty decarbonization of the blood and is found in organic diseases of the lung and liver, especially pleuro-pneumonia and pulmonary tuberculosis.

Iridescence occurs in blood diseases, prolonged fevers, inflammatory affections, and parturition. Green color denotes decomposition, gangrene, diffusion of vegetable coloring matter, medicinal agents, the escape of the contents of the stomach and intestines during evisceration and in the abdominal muscles when evisceration is delayed for some time, and yellowish-green when the bile escapes from the gall bladder.

The marrow in temperate climates should be free from pigmentation or hemorrhagic spots. In the hind legs it is of firm consistence and rosy red; in the forelegs it is diffluent and of a lighter color.

Pickled Meats. Flesh intended for pickling should be perfectly healthy, fresh, and, when feasible, "boned." The pickling process should be thoroughly and carefully done. Proof of faulty pickling may be detected by a superficial examination, but often it will be necessary to make deep incisions, and the inspector should be particular to examine into the condition of the tissues contiguous to bones.

Salted meat may give rise to poisoning from any of the following causes: (1) well salted but diseased meat, (2) well salted but old meat, (3) imperfect or bad salting. In the first, its noxious character may depend upon the toxines or other poisonous substances which are not destroyed by the pickling process, in the second, it will probably depend upon chemical changes that may take place, and in the third, will result upon the development of bacteria or from poisonous chemical products developed in the meat. If brine is used several times, it may acquire poisonous properties. In July, 1880, an outbreak of poisoning occurred in Wellbeck and Notts. Ballard investigated the outbreak, and reported that seventy-two persons were attacked, and four cases terminated fatally. The symptoms were marked prostration, vertigo, nausea, griping pains in the abdomen, pains in the chest, and diarrhea. Klein assisted in the investigation, and he states that the necropsy, in the four fatal cases, revealed marked evidence of pulmonary and intestinal inflammation. The kidneys were involved, as proven by microscopic examination; the uriniferous tubules contained hyaline casts, and the afferent arterioles and capillaries of the glomeruli were filled with bacilli. Culture inoculations were made, and the cause, a bacillus from 0.003 to 0.009 mm. long, and 0.0013 mm. thick, with rounded extremities, isolated. Upon the slide these bacilli were arranged singly and in chains, and in some of them spores were seen.

Sausage Poisoning. Many theories have been advanced as to the nature of the active agent in sausage poisoning (botulism, allantiasis).

The bias of the scientific mind favors the theories which ascribe to bacteria or their ptomaïnes the noxious properties. Van den Corput has described a microörganism (sarcinia botulin) which he believes to be the active agent. Müller and Hoppe-Seyler have discovered divers microörganisms in meat. Gaffky and Back investigated cases of poisoning following the eating of sausage the ingredients of which were horse flesh and liver. They isolated a short, thick bacillus, which, when administered to animals with the food, injected subcutaneously or intravenously, produced symptoms identical with those observed in the original cases. The symptoms were those of intense intestinal irritation with marked prostration. Some authorities assert that putrefying sausages have a "dirty, grayish-green color and a soft, smeary consistency," an odor resembling putrid cheese, an unpleasant taste, and impart to the mouth and pharynx a burning sensation.

For proving the presence of a poison, microbic in origin, no reliable and speedy test is available where the symptoms appear within two to six hours after the ingestion of the meal. Each separate dish of which the meal was composed should be examined and a physiological test made. This is usually best accomplished by feeding the suspected food to an animal, for which purpose the dog is best adapted.

Fowls. The fowl used for food may be either wild or domestic (poultry). The difference between the two probably lies largely in the character of the food upon which they have subsisted. The flavor is certainly almost exclusively dependent upon the diet, and for this reason the so-called game fowls, such as the quail and wild duck, are the richer and tastier, while the domestic fowl is, as a rule, the fatter and equally readily digested. The chicken represents very nearly the composition of the turkey, the goose that of the duck, and the partridge that of the wild fowls. The subjoined table gives proportionately the proximate principles found in each.

	Water.	*Albuminates.*	*Fat.*
Fat chicken,	70.03	23.32	3.15
Fat goose,	38.02	15.91	45.59
Partridge,	71.96	25.26	1.43

The domestic turkey and chicken and the game fowls are admirably adapted for food, but the domestic goose contains such an enormous quantity of fat as to be rarely commendable. The game fowl has become a luxury, and, it is to be regretted, rarely calls upon the food inspector for review.

Inspection of Poultry. The diseases which affect poultry, and to which man is susceptible, though few, are of the utmost importance.

Tuberculosis. All domestic fowls, and chickens in particular, are very susceptible to tuberculosis. Diseases which were formerly diagnosticated "croup," "roup," "gregarinosis," and "diphtheritic aphtha" were, in fact, nothing less than tuberculosis.

Tuberculosis, usually, first manifests itself upon the mucous membrane of the mouth, nostrils, or eye, as a croupous or diphtheritic membrane. The exudate from these parts forms upon the surface a lamellated membrane of a yellow color. The membrane is firmly adherent to the superficial mucosæ, and if it be forcibly removed a raw, bleeding surface remains. From the mouth the false membrane extends to the crop, and the latter involves the proventriculus and the lower portions of the alimentary canal; it then extends to the mesentery and ultimately to the liver. When any portion of the alimentary canal becomes infected nodes develop, and they may be found varying in size from a pin's head to a walnut. Ulceration of the intestines frequently occurs; and sometimes the lumen of the intestine is occluded by the formation of a membrane similar in character to the one above described. The lesions in the mesentery, liver, and spleen are always nodular, and the nodes may develop to such considerable dimensions as to completely suspend the functions of the organ. The throat and lungs become involved by extension of the process from the nostril, and the eyeball by extension from the conjunctiva. The spleen is frequently the seat of this disease; the kidneys and testicles are sometimes affected, though usually as the result of metastasis. The heart is never affected. The breast and feet are at times the seat of local tuberculosis, infection having occurred through the fowls perching upon infected roosts or in receiving wounds with infected pieces of glass, nails, etc., which may be found strewn about the poultry yard.

Diphtheria of Pigeons and Chickens. It is not as yet determined beyond all controversy that the diphtheria of pigeons and the diphtheria of chickens are not identical with the diphtheria which afflicts man.

In pigeons the parts usually affected are the base of the tongue, the fauces, and corners of the mouth; while in chickens the most frequent seats of the disease are the tongue, the nares, the larynx, and conjunctiva.

The first manifestations of the disease are small patches of inflammation upon the mucous membrane of the mouth and fauces. Later at these patches exudation occurs with the formation of a pseudo-membrane which is stratified, becomes somewhat thick, and is of a yellow color. From the outset there is fever and symptoms of poisoning. The malady is very fatal among pigeons and chickens, and the young especially are extremely susceptible. The demonstration of the bacillus of diphtheria in the lesions would, of course, settle the question of condemnation.

Fish. The varieties of fish utilized for food are almost innumerable. There is but very little material difference between the individual varieties in the nutritive value, and as given by Chapman the composition is about as follows:—

Water,	740.82
Albumin,	137.40
Collagen,	43.88
Fat.	45.97
Extractives.	16.97
Salts,	14.96

Fish, besides being highly nutritious, is easily digested, and, as suggested by Parkes, the supply of phosphorus makes it eminently a fitting diet for brain workers. The theory that diseases of the skin, including leprosy, originate from a constant fish diet, does not seem to be substantiated by any known facts. Fish roe is highly nutritious; the hard variety consists of the ovary of the female fish, while the soft roe is the spermatic organ of the male and is known as the "milt."

Oysters and *mussels* are usually considered with fish, although belonging to a separate group, the mollusca. Oysters present about the following composition, as given by Chapman:—

Water,	80.385
Nitrogenized substances,	14.010
Fat,	1.515
Salts,	2.695
Loss,	1.395
	100.000

In selecting fish for food, it is important that it should be perfectly fresh, as there is probably no other food which undergoes such rapid decomposition. If there is any evidence of decomposition, any blubbering at the gill, dryness or slipping of the scale, or any odor, not that peculiar to the individual variety under inspection, or if icing has not been thorough since the catching, the fish should be rejected for food. Wherever possible, fish should be kept alive as long as circumstances will permit, and preferably only killed immediately prior to being cooked.

It seems not improbable that fish, oysters and mussels possess the faculty of retaining poisonous products engendered by the water in which they are found. Whether they merely absorb and retain this poisonous property or whether it is engendered within the organism during life or immediately after death has not as yet been definitely determined. Poisoning as developed from mussels has been studied most carefully. Thus in the *British Medical Journal* for September 15, 1888, the following case was reported, which may be said to be typical of this class of cases. A shipwright, fifty years of age, collected a quantity of mussels which had adhered to the bottom of a float. He ate three or four quarts of them, some boiled, and some raw. Within a few hours the symptoms evinced themselves; he was attacked with violent abdominal pains accompanied by vomiting; unconsciousness rapidly developed with perfect relaxation of the muscles, including those of respiration. By the aid of artificial respiration he was kept alive for six or seven hours. At no time did the respiratory functions reassert themselves, and death took place in less than eight hours after the ingestion of the poison.

Mussel poisoning is said to take place most frequently during the summer months and rarely in winter. Brieger believes that he has isolated from the mussel a poison belonging to the group of ptomaïnes, to which he gives the name of *mytilotoxin.* He believes that it is developed in the liver of the mollusca. As the liver possesses a peculiar faculty of storing up toxic elements, Brieger's discovery does not establish the generation of the poison in the liver, and therefore leaves us much in doubt as to its probable source. As this poisonous principle seems to be engendered only in contaminated water, and not always by any individual member of the mollusca family, it would seem that water pollution is an essential factor in its development.

Potatoes, Carrots, Cabbage, Beets, and Turnips. These represent very common and widely used vegetables, all having a more or less definite composition with slight variations dependent no doubt upon soil and variety. The potato is rich in starch and contains a relatively small quantity of salts. The starch digests with readiness and yields an abundance of vegetable acids and their combination with potash, soda, and lime. By reason of their keeping qualities as a fresh vegetable, potatoes are probably more extensively used than any other member of the group. Where no other vegetable is taken, Parkes advises that at least from ten to twelve ounces of potato should enter into the daily diet. The composition of the potato as given by Chapman is as follows:—

Water,	66.876
Starch,	30.469
Albumin,	0.503
Gluten,	0.055
Fat,	0.056
Gum,	0.020
Asparagin,	0.063
Extractives,	0.921
Potassium, chlorid,	0.176
Iron,	
Manganesium,	
Albuminium, Silicates,	
Sodium, Phosphates,	0.815
Potassium, Citrates,	
Calcium,	
Free citric acid,	0 047
	100 000

In the selection of potatoes, Parkes recommends that the specific gravity be taken as the determining factor of quality, and gives the following table:—

Below	1068	the quality is	very bad.
Between	1068—1082	" "	inferior.
Between	1082—1105	" "	rather poor.
Above	1105	" "	good.
Above	1110	" "	best.

The specific gravity is best obtained in a solution of common salt, having a known density. The potato should have shallow eyes and there should be no evidence of fungoid growths. Cracking or fissuring of the surface is usually brought about by too long exposure in the sun immediately after digging, or too low a temperature before sufficient drying has taken place. Both materially deteriorate the vegetable.

The *Sweet Potato* differs in its composition from the ordinary potato in that it contains a little more than half as much starch and in addition about ten per cent. of sugar. It does not possess so good keeping qualities, cannot be cooked with animal foods, and is less easily digested than the ordinary potato.

The *Yam* is closely allied to the sweet potato, but contains more starch and very much less sugar.

Carrot. The composition of the carrot as given by Yeo is: water 85 to 88 per cent., about eight per cent. of carbohydrates, including a variable quantity of sugar, one per cent. of salts, and slightly over one per cent. of proteid matter. The parsnip presents about the same composition as the carrot, but is not so extensively used as a food.

Beet roots afford one of the most nutritious vegetables, containing about ten per cent. carbonaceous and one and one-half per cent. of nitrogenous matter, with about one per cent. of salts.

Cabbage. The group of vegetables to which cabbage belongs presents a remarkable fact in that the order (Cruciferæ) is said not to possess a single poisonous plant, a botanical fact, as Yeo remarks, of great importance to those searching for food in unfamiliar countries. The order includes the various forms of cabbage, cauliflower, broccoli, and salad, vegetables useful largely for their anti-scorbutic properties, and possessing but little nourishment.

Cereals. The *Cerealia* represent the largest number of vegetable foods, including barley, maize, rice, rye, wheat, and millet. The indigestible element in the cereals is the cellulose, oats containing the largest quantity of this element and rice the least. The special valuable food constituents are the vegetable albumin, fat, starch, and sugar. In the process of making flour and meal, the outer hull, composed for the most part of cellulose, is removed. In America, wheat and maize (Indian corn) are utilized almost exclusively for bread, while in Europe, rye and barley replace to a certain extent the corn. The following table gives the approximate food value of the grains as constructed from tables in Yeo taken from Bauer:—

	Nitrogenous Substances.	Fat.	Starch, Sugar, Gum, etc.	Cellulose.	Ash.	Water.
WHEAT,	12.42	1.70	67.89	2.66	1.79	13.56
" (finely ground),	8.91	1.11	74.28	0.33	0.51	14.86
" (coarsely ground),	11.27	1.22	73.65	0.84	0.84	12.18
RYE,	11.43	1.71	67.83	2.01	1.77	15.26
" (finely ground),	10.21	1.64	73.54	0.64	0.98	13.99
" (coarsely ground),	11.06	2.09	67.78	2.61	1.69	14.77
BARLEY,	11.16	2.12	65.51	4.80	2.63	13.79
" MEAL,	10.89	1.23	71.85	0.47	0.63	14.83
PEARL BARLEY,	7.25	1.15	76.19	1.36	1.23	12.82
OATS,	11.73	6.04	55.43	10.83	3.05	12.72
OAT MEAL,	14.29	5.65	65.73	2.24	2.02	10.07
MAIZE,	10.05	4.76	66.78	2.84	1.69	13.88
" MEAL,	14.00	3.80	70.68		0.86	10.60
RICE,	7.81	0.69	76.40	0.78	1.09	13.23
" (ground),	7.43	0.89	77.62			41.15

Barley and oats, although containing valuable nutritive elements, are rarely used as foods in this country, except as component parts of soups. In Scotland, however, they are largely used; they possess a high nutritive value. Rice differs from other cereals in that it possesses a comparatively low percentage of proteid matter, 3 to 7.5 per cent., and an extremely small quantity of fat, less than 1 per cent., while at the same time it contains an enormous amount of starch, varying between 70 and 80 per cent. The starch is easily digested and readily prepared for the table.

Buckwheat, which is largely used in this country as a food, is not a member of the cereal family, but belongs to the natural order of Polygonaceæ. Its composition as given by Bauer is as follows:—

Water,	14.27
Nitrogenous substances,	9.28
Fat,	1.89
Starch, cellulose, etc.,	70.68
Ash,	0.96

Although somewhat indigestible as ordinarily prepared, buckwheat contains abundant nutritive elements.

Peas and Beans. (Nat. Ord. Leguminosæ.) The members of this group contain a large quantity of nitrogenous matter, as vegetable casein and albumin, together with starch, and better than any other vegetable can be utilized as a substitute for animal food. Peas and beans are richer in inorganic salts, including the combinations of sulphur, phosphorus, soda, potash, lime, and magnesia, than the cereal grains. The composition of beans and peas is as follows:—

	Peas.	*Beans.*
Water,	14.31	13.60
Nitrogenous substances,	22.63	23.12
Fat,	1.72	2.28
Starch, etc.,	52.24	53.63
Cellulose,	5.45	3.84
Ash,	2.65	3.52

Dried peas and beans are also utilized as a food, and, although their digestibility is reduced by the drying process, their nutritive value is but little altered. Rarely are peas and beans adulterated; reduction in food value often results from deficient quality and long over-ripening, making the vegetable much harder to digest. Occasionally when dried they may be infested by insects.

Fruits. Fruits vary enormously in their nutritious properties, but fulfil the requirements for variation in diet, supply salts, vegetable acids, and other anti-scorbutic agents. They also have the advantage of being readily tinned, preserved, or dried. (See Condensed, Tinned, Dried, and Preserved Foods.) The following table as given by Yeo after Bauer approximately presents the composition of the most commonly used members of the group:—

	Apple.	Pear	Peach.	Grape.	Strawberry.	Currants.	Orange Pulp.
Water,	83.58	83.02	80.03	78.18	87.66	84.77	89.01
Nitrogenous matters,	0.39	0.36	0.65	0.59	0.07	0.51	0.73
Free acid,	0.84	0.20	0.92	0.79	0.93	2.15	2.44
Sugar,	7.73	8.26	4.48	24.36	6.28	6.38	4.59
Other non-nitrogenous matters,	5.17	3.54	7.17	1.96	0.48	0.90	0.95
Cellulose and kernel,	1.98	4.30	6.06	3.60	2.32	4.57	1.79
Ash,	0.31	0.31	0.69	0.53	0.81	0.72	0.49

It would seem from a study of food values that the presence of the vegetable acids is the most important factor in estimating the value of this group. Apples, pears, gooseberries and peaches yield malic acid, lemons and oranges citric acid, while tartaric acid and the tartrates are supplied largely by the grape.

Fruits should be secured fresh and never green, with the exception of gooseberries and currants, which are sometimes utilized for pies and pastry in their green state. No fruit in any stage of decomposition should be used for food. Many fruits which are not only healthful, but nutritious in their native climate, are undoubtedly made less healthful, if not actually injurious, by the necessity of transporting them prior to their natural ripening and imitating this by artificial processes. The banana typifies this group. When fruits are brought from a warmer to a colder climate, in order to supply the market prior to the ripening of the product in that zone, it may be laid down as an almost invariable rule that such fruits are not innocuous.

Foods, Evaporated, Tinned, Condensed, Preserved, etc. Among the foods are several which may be either *evaporated*, *condensed*, *tinned*, *or preserved.*

The *evaporated* foods consist largely of evaporated fruits, such as apples, peaches, occasionally pears and berries. Considerable loss takes place in weight, representing the loss in aromatic principles (ethers) and water. The evaporation may be secured at low temperatures exposed in a dry atmosphere, and when so prepared the article is sold as dried fruit, or at higher temperaures in dryers, when it is known as evaporated fruit. The former is to be preferred.

COMPOSITION OF DRIED FRUITS.

	APPLE.	CHERRY.	RAISIN.	FIG.
Water,	27.95	49.88	32 02	31.20
Nitrogenous matter,	1.28	2.07	2.42	4.01
Fat,	0.82	0.30	0.49	1.44
Free acid,	3.60	. .	. .	1.21
Sugar,	42.83	31.22	54.26	49.79
Other non-nitrogenous matter,	17.00	14.29	7.48	4.51
Cellulose and seeds,	4.95	0.61	1.72	4.98
Ash,	1.57	1.63	1.21	2.86

Meat may be dried at a low temperature, either in mass or finely divided, in which case it is afterward reduced to a powder. In mass, it is hard, firm, tough, semi-elastic, and while it may be palatable, it is difficult to cook, and as eaten raw, is liable to communicate disease. Various forms of meat are preserved by drying, some are sold as powders, others in strips which are known as "jerked" meat strips, the meat having been cut in strips, dipped in brine, and hung up to dry; occasionally they are dried without dipping in brine.

Milk may be evaporated to dryness and sold as a powder, although it is digested with difficulty. *Bread*, *crackers*, including *biscuits*, may be evaporated to dryness and sold as powders or in compressed cakes; occasionally the powders are mixed with powdered meat, sometimes with vegetables. Rice, potatoes, beans, etc, are sometimes cooked, evaporated, and sold in powder form, either alone or mixed with nitrogenous food. Egg albumen may be evaporated to dryness; occasionally the whole egg is mixed with cracker dust, evaporated and preserved in that manner. The yolk, however, does not keep well and proportionately lessens the keeping properties of the mass.

Among the condensed and concentrated foods we have the different forms of condensed milk, extracts of meat, meat juices, clam and oyster juices, either evaporated and seasoned to the consistency for keeping or sealed in bottles or jugs, more rarely in tin cans. Among the many forms of condensed milk, that having the best keeping properties, after opening, is that to which has been added a varying quantity of milk-sugar or more commonly cane-sugar. As a rule, the milk is condensed to about one-fourth its volume. Although further condensation is claimed, it is rare that such claims are well founded. Of the various meat extracts, those following the formula of Liebig, or some modification, are deserving of the most consideration. The viscid extract, darkish in color, which is obtained by Liebig's process, consists of the salts, some albumin, creatin, some blood, corpuscular elements, and a mixture of other nitrogenous substances. Armour's American product closely resembles Liebig's Extractum Carnis, as does various preserved juices, such as Johnston's, Carnrick's, Valentine's, Murdock's, and other forms, usually utilized as readily available foods. Occasionally peptones, which are but some of the forms of semi-digested meats, may be used as forms of condensed or concentrated foods.

Of the tinned foods, we now-a-days have nearly all the vegetables tinned, many of the meats tinned, including fish and oysters. The tinned food products may be considered as having about the same nutritive value as the raw, provided that the quality of the material tinned is equally high; they are, however, not so easily digested.

Adulteration of Tinned Foods. Dr. Leffmann is of the opinion that copper, while rarely present, when used for coloring peas and similar vegetables is in such a small quantity as to be insignificant. Aside from the dangers attributable to decomposition, foods may contain acids which, by acting on the lead or tin, produce poisonous salts; practically, lead does not enter into the question, as Leffmann and Beam have not found evidence of lead salts in a single instance. The poisonous salts usually consist of some combination of a vegetable acid with tin.* Where suspicion may arise as to tinned goods having given rise to poisoning, any of the remaining product may be strained or filtered, or both, and the filtrate treated with a solution of hydrogen sulphid; if any of the poisonous metals be present, a precipitate of the sulphid will occur. The salt present can then be determined in the usual manner. In meat, the poison is usually that due to some of the bacterial alkaloids, known as ptomaïns. Entirely reliable chemical tests are not as yet forthcoming for the detection of these products, and so far as experience in the matter goes, it seems probable that the feeding of suspicious material to an animal will afford the most reliable clue. Given

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* *Bulletin No. 13, Part 8, Canned Vegetables*, just issued, apparently shows an alarming amount of food adulteration, both intentional and unintentional. In the former would be included the greening of vegetables by the use of copper or zinc, the addition of antiseptics, such as salicylic acid and sulphurous acid, to secure preservation, while the latter embrace lead and tin and other accidental contaminating agents. The investigations, while showing the wholesale character of the sophistications, does not establish the presence of these agents in toxic quantities, although there can be no doubt that the continuous use of some of the brands must be not only deleterious but dangerous. The advised course is for the State to require all such foods to be distinctly labeled with the name and quantity of the sophisticating agent. This is not likely to occur, no matter how important it may be, as a government which does not care to know the composition of proprietary medicines, and quack cancer and consumption cures, is not likely to push the pure food demand.

a canned product suspected of containing deleterious agents, a portion of the filtrate may be treated with hydrogen sulphid and the solid portion of the food fed to an animal; in the absence of metallic poison, the presence of an alkaloidal poison may be established by the induction of symptoms in the animal identical with those found in man.

Preserved foods are foods in which decomposition is prevented or retarded by the addition of sugar, oil, salt, etc.; of the first group, fruits are examples; of the second, sardines; of the third, salted meats, etc. As a rule, they are wholesome and nutritious, depending almost entirely upon the quality prior to the preserving and the preservants used. Sugar and candied fruits, jellies, etc., belong to this group. So far as known, they are usually pure, provided the process has been thorough, otherwise decomposition invariably sets in.

Sterilized Foods. These consist of foods rendered sterile by thermal or chemical germicides, and reinfection prevented by excluding the air, as in sealing, excluding the bacteria by means of cotton wool closure of the containers. The sterilization is usually accomplished by means of repeated steaming (thermal disinfection), although sulphurous acid has been found of some value. Commercially the process has not been found feasible, although canned foods are practically sterilized.

Refrigerated Foods. Preservation of foods by cold, either natural or artificial, has assumed astounding commercial magnitude. Dressed meat is now shipped the entire breadth of the continent, and even across the ocean, in chilled containers, the extremely low temperature being maintained with great exactitude by means of ice machines constructed for the purpose. Eggs, butter, meats including game and fowls, also fruits and vegetables, are kept for months by this process. Occasionally the preservation is favored by a slight salting. If properly applied the process itself does not threaten either the nutritive value nor the healthfulness of the foods. Great danger lies in irregular temperatures or a temperature not sufficiently low, and in the faulty ventilation of the compartments and poor condition of the foods prior to the attempted refrigeration. So far as known, no evil consequences have been observed as proven to arise from foods which have been subjected to refrigeration.

Tea. Tea consists of the dry leaves of a plant, indigenous in Japan, China, India, and Ceylon. The varieties of tea differ somewhat, depending upon the country from which the variety comes, also the stage of growth at which the leaf was picked and the treatment of the leaf after picking. The active principle in tea is thein, an alkaloid of which the leaves yield from 1.15 to 1.5 per cent. Thein exists in the leaves in combination with a tannic acid of which from 12 to 23 per cent. will be found present. The effects of tea upon the digestion are largely dependent upon the quantity of tannic acid which it contains. Samples of tea which yield more than 15.5 per cent. of tannin should not be used as a beverage, and the more nearly the per cent. of tannin approaches 12 per cent., the better the tea. Tea contains a small quantity of ethereal oils, but not in sufficient amount to merit consideration. As a rule, the higher-priced fine China teas yield relatively a smaller amount of tannin than the Indian varieties.

Tea is a stimulant, a quality dependent upon the quantity of thein present. Tea relieves hunger, lessens the sense of fatigue, and seems to increase the power of endurance. If taken in excess during or after meals, the tannin may interfere with the digestive processes, by precipitating the digestive ferments. Tea should be administered in the form of an infusion, quickly drawn and containing about five parts of the dry leaves to one hundred parts of boiling water. The green tea is preferable to the black tea.

Tea adulteration consists largely in the recoloring of exhausted leaves by the use of powdered catechu, with or without the addition of gum or starch. It is said that the Chinese add magnetic oxid of iron and occasionally sand to the tea; the latter ingredient may be suspected when the ash rises above six per cent., while catechu and starch may be recognized under the microscope by moistening the powder on a glass slide with a small quantity of glycerin. Iron may be detected by dissolving the powder in strong hydrochloric acid and treating the solution with ferricyanid of potassium. In old tea, acari, fungi, and bacteria may be found. The percentage of thein may be obtained by exhausting the leaves with boiling water, filtering, adding a solution of subacetate of lead, again filtering, treating with hydrosulphuric acid, and removing the excess of lead, again filtering and evaporating the filtrate short of dryness; add a trace of ammonia and more water, filter through animal charcoal, to decolorize; the filtrate is then evaporated slowly until crystallization begins, when the evaporation is continued on a tared filter in an oven at a low temperature; by weighing the residue the percentage of thein may be readily obtained.

Coffee. Coffee used as a beverage consists of the fruit of *Coffea arabica.* The seeds are roasted at a temperature of from 175 to 200° C., which converts the sugar into caramel and develops the aroma by bringing out the volatile aromatic products. The heat also engenders certain gaseous materials which increase the size of the berry while the driving off of the water diminishes its weight. By reason of the transient character of the aroma, coffee should be freshly roasted, and ground only when ready for use, although, if tinned in small packages, it may be preserved indefinitely. It is not probable that coffee acts upon tin as was once supposed. In the composition of coffee we find caffein, an alkaloid identical with thein, combined with caffeic and tannic acid, the latter much less in quantity than in tea; unlike tea, it is probable that the physiological effects of coffee are largely due to the ethereal oils present as well as to the caffein. The percentage of the alkaloid in coffee is very much less than in tea, on an average about one-half.

While tea is usually taken as an infusion, and in the most parts of Europe, coffee as well, Dujardin-Beaumetz maintains that the decoction is preferable, as it preserves the nutritive, stimulant, and tonic effects, and lessens the manifestations usually observed in the nervous system. A mixture of a decoction and infusion is preferable and may be made in the following manner: Boiling water is poured over the coffee, and after standing for about five minutes, is drawn off; more water is added to the coffee, which is now boiled for ten or fifteen minutes; the decoction thus made is strained off and added to the previously prepared infusion. For each meal 200 grains, or about a heaping tablespoonful, of ground coffee should be allowed for each individual. For soldiers on the march this should be increased about one-third. Like tea, coffee diminishes the sense of fatigue and apparently augments the muscular activity. It stimulates the heart, increases the secretions of the kidney and of the skin, increases the excretion of urea and probably to a very slight degree raises the temperature.

In the selection of coffee, that variety possessing the most agreeable aroma after roasting is to be preferred. The microscope readily detects adulteration in coffee, the histology of the bean being strikingly characteristic. The tissue of the berry is stroma-like, the interstices containing angular masses and oil globules. It is probable that in this country the most extensive adulteration of coffee is by the addition of artificial coffee, made by browning a compressed bean, made in imitation of the coffee berry, from earth and corn or wheat flour. The imitation berry possesses a much higher specific gravity and on fracturing presents an entirely different surface from the coffee bean ; if thrown into water it rapidly disintegrates. It increases enormously the percentage of ash, and where ground in with the coffee, the ash may reach as high as 10 to 12 per cent. The chicory berry is commonly used as an adulterant of coffee and may be readily detected by the microscope. The chicory infusion is of a specific gravity from 1018 to 1020, while coffee ranges between 1008 and 1012. The berry sinks immediately in water, while coffee floats for a short time. Coffee yields about 4 per cent. ash, four-fifths of which is soluble in water, while chicory affords five per cent. of ash, only one-third of which is soluble. Chicory contains from 10 to 20 per cent. of sugar, while roasted coffee rarely contains more than one per cent. The additions of cereals and starches may be readily detected by testing with iodin for the presence of starch.

Coffee is sometimes made from so-called extract or essence, but a good quality of coffee extract or essence is at present not a commercial commodity. The temptation to adulterate and the facility for detecting such adulteration are so out of proportion that we have little hope for advance in this direction.

Alcoholic Beverages. In considering alcoholic beverages one is confronted on the threshold by the question, widely discussed by physiologists, as to whether alcohol is a food. Upon this subject physiologists are divided, many maintaining that alcohol passes through the system without being utilized as a food, merely acting as a stimulant in the same sense as many medicaments ; another group classify alcohol as among the easily available foods, maintaining that by oxidation the alcohol is converted into carbon compounds. One group maintains that it hastens tissue oxidation, and the other that it retards tissue waste by undergoing oxidation itself. Without discussing this matter it seems not improbable that the action of alcohol is dependent largely upon the quantity ingested, and the difficulty which practically presents itself is the danger of its abuse. Evidence is not wanting to prove that the abuse far exceeds in detriment the possible advantages which may arise from its indiscriminate application as a food. Like all other stimulants its over-stimulation leads to exhaustion, and its good qualities are thus imperiled by its abuse. Unlike other stimulants, over-stimulation is, to a large majority of mankind, a pleasant and exhilarating sensation, and therein lies the danger.

As a food, Yeo, in sympathy with Parkes and others, believes that the minimum amount of alcohol, whether in form of spirits, wine, or beer, which should be taken by a healthy adult, should not exced one and one-half fluidounces in the twenty-four hours. In this amount it is believed to be a stimulant to the circulatory, respiratory, and nervous systems, increasing the appetite and facilitating digestion. In any excess of this, alcohol leads to the development of catarrhal and fibroid changes in the digestive organs, more particularly the stomach and liver, thus altering the character and diminishing the quantity of the secretions upon which digestion so much depends. Alcohol leads to permanent alterations in nervous matter, more particularly that of the central organs, the brain, and spinal cord.

Dujardin-Beaumetz points out that the higher the atomic weight, the more toxic the alcohol, in support of which the following members of the group may be adduced :—

Methylic alcohol,	CH_4O
Ethylic "	C_2H_6O or $CH_4O + (CH_2)$
Propylic "	C_3H_8O or $CH_4O + 2\,(CH_2)$
Butylic "	$C_4H_{10}O$ or $CH_4O + 3\,(CH_2)$
Amylic "	$C_5H_{12}O$ or $CH_4O + 4\,(CH_2)$
Caproic "	$C_6H_{14}O$ or $CH_4O + 5\,(CH_2)$

Spirits (" ardent spirits ") are distilled fermented juices from fruits, vegetables, and cereals. Of the fruits, apple, grape, cherry, and peach are most commonly used ; of the vegetables, potatoes, although none of this group are in frequent use ; of the cereals, wheat, rye, barley, maize, and rice are mostly used, wheat and corn in this country, barley and rye in Scotland and Ireland. The composition of spirits is fairly constant in the quantity of alcohol, about 50 per cent., which they contain, combined with various aromatics, depending upon the source.

The alcohol in spirits may be contaminated by the presence of amyl alcohol or fusel oil, a highly injurious and poisonous compound. Bartholow, in accord with Richardson, believes that amyl alcohol is, probably, the most active of the group in the production of delirium tremens, and remarks that "amyl alcohol causes tremors and muscular twitching identical with the tremors observed in the human subject during the alcoholic disease known as delirium tremens."

Wines. The term wine is applied to the fermented juice of the grape, for which it was once exclusively used, but at present it includes the juices of many of the saccharin fruits, including the orange, gooseberry, currant, cherry, etc. The *bouquet* of wines is dependent upon the presence of ethers and extractive matters. Œnanthic ether is most constantly present. The coloring of wines is dependent upon the fruit which is used also upon whether the skins are extracted as well as the pulp of the fruit. The sweetness in wines is dependent upon the presence of saccharin matters, while the exhaustion of these by the abundant production of alcohol at their expense gives rise to acidity. Besides the water, alcohol, and ether, wines contain sugar and tannin, essential oils, coloring matters, salts, acids, and extractives. The percentage of alcohol in wines varies within enormous limits. Sherry comes highest, with over 20 per cent. of alcohol, and the Rhine wines lowest, with from five to six per cent. The most pleasant wines, and as a rule those having the best quality, rarely exceed ten per cent. of anhydrous alcohol.

Beer, Ale, and Porter. The so-called malt liquors are manufactured from malted grain, usually barley. The malting process is accomplished by allowing the grain to germinate at a suitable temperature in the presence of moisture. During germination diastase is produced which converts the starch of the grain into dextrin and sugar. The germination process is then stopped by heating, the malt is dried either at a low temperature, 120° F. to 140° F., in which instance a pale malt is produced, or at a high temperature by which the malt is blackened; the latter is used in the manufacture of the darker members of the series, such as porter and stout. In the manufacture of beer, an infusion is made of the malted grain, to which is added hops; the mixture is then boiled, cooled, and placed in vats where alcoholic fermentation is established by means of yeast. The percentage of alcohol in the beer is dependent upon the amount of converted starch in the infusion or "wort" and the extent to which fermentation has been allowed to proceed. The coloring of the beer is largely dependent upon the malt which is used. The composition of beer as given by Chapman is as follows:—

Water,	947.00
Alcohol,	4.50
Dextrin, glucose, etc.,	41.40
Nitrogenized substances,	5.26
Mineral salts,	1.48
Bitter principle not determined,	
	1000.00

The percentage of alcohol varies within rather wide limits; thus in the heavier English beers as much as 12 per cent. of alcohol may be present; in the lighter and more pleasant beers the percentage will range from 1 to 6.

The acidity of beer is due to the presence of acetic acid, augmented by lactic, malic, and gallic acids in small quantities. The malt extract, which includes the dextrin, glucose, etc., varies from 5 to 14 per cent.; it is highest in porter, to which a large amount of nutritive value is attributed. The amount of carbonic acid present is dependent upon the temperature as well as upon the brewing, packing, and shipping; thus at a low temperature more carbonic acid will be contained than in high. Draft or keg beer will have a higher percentage than bottled beer. This is brought about in keg beer by adding bicarbonate of soda just before the bung is driven; the acetic and lactic acids in the beer combine with the sodium and liberate the carbonic acid which remains in the beer, constituting what is known as the "head." Beer differs from spirits and also from wines in that it is not only a stimulant and tonic, but contains nutritive principles in the shape of sugar, dextrin, etc. It seems not improbable that the ferment in beer assists in the digestion of starches. The stomachic tonics are the light beers containing the largest quantity of bitter principle and the smallest quantity of extractives. The greatest amount of concentrated nourishment is found in the beers containing the largest proportion of extractives with a relatively small proportion of alcohol. To the latter group belongs porter. The adulteration of malted liquors is probably most extensive. Malt of the lowest quality is often used, the diastatic properties but poorly developed, and sugar added in order to supply material for fermentation, or rice may be used to supplant the barley. Instead of hops as the bitter principle, aloes, picric acid, and picrotoxin are used. The coloring is accomplished by caramel and the foam by glycerin or soap bark.

Koumiss, a fermented beverage introduced from Tartary, where it has long been known. Originally it was made from the milk of mares, but as introduced in this country and in England is made from cows' milk, the fermentation depending upon the breaking up of the lactose into alcohol and carbonic acid.

Kefir is very closely allied to koumiss, and is said to contain less alcohol than koumiss with equal nutritive value. They are both used largely in the dietetic treatment of disease, and while but slightly stimulant are rich in nutritive matters, easily digested, readily assimilable, and usually well borne by the most delicate stomach. Recently there has been introduced a dry koumiss, under the name of "koumissgen." It is said to be made from milk, predigested and evaporated, the "head" of carbonic acid being secured by effervescing salts intermixed in the dry or anhydrous state. It, of course, contains no alcohol.

DIET.

Diet may be defined as a systematic arrangement or selection of food; in other words, a practical application of the information already given in the general consideration of food.

The salient factors to be considered in connection with diet are, *age*, *sex*, *climate*, *occupation*, *appetite*, *administration*, *cooking*, *digestibility*, *idiosyncrasy* and *quantity demanded.*

Age. Prior to the second year, the food should consist exclusively of milk, after this period the farinaceous foods should be added. The quantity may be based upon the relative weight and compared in food values with a little higher diet than the subsistence diet laid down. The alkaloidal and ardent beverages should be interdicted. After about the tenth or twelfth year the proportion of fats may be increased. It must be remembered that for young adults, at labor, a more generous diet will be demanded, proportionately, than for an adult, as they must supply not only force, but construct tissue simultaneously.

Sex. There is little ground for believing that there is any difference, except a relative one, between the two sexes, provided an equal amount of labor is exacted. It would seem probable, however, that by reason of the catamenia the female will require a more generous diet than the male, in proportion to her weight and the work done.

Climate. An important feature to be borne in mind is the relation of external temperature to the amount of heat which must be generated by the organism. Thus in polar latitudes with extremely low temperatures, it will be necessary, in order to produce sufficient heat to maintain life and restore that lost by radiation, to use large quantities of carbonaceous food, the oxidation of which will produce the necessary degree of heat; on the other hand, in warm climates, the surrounding temperature being relatively high, food which contains but little carbon will be demanded; hence, in the Arctic regions, the inhabitants subsist on oily foods derived largely from the whale, while in the tropical climates, fruits and similar foods containing less carbon are sufficient. It is also to be observed that changes in season with the accompanying changes in temperature demand also variations in diet. Thus in winter the food will more readily approach the constant diet of the extremely cold latitudes, and in summer that of the warm countries, and hence, as Chapman remarks, fats and sugar will be more needed by the system in January than in July.

Occupation. In a previous chapter attention has been drawn to the difference in the exercise demanded by those engaged in active physical exertion and those living a more exacting psychical life. The kind and amount of food will, no doubt, influence to a great degree the activity in one or the other direction. Where great muscular activity has to be manifested and abundance of force utilized, a carbonaceous diet will be required to supply the needs in that direction, while if muscular exercise and physical activity be reduced to a minimum, but a small quantity of carbon will be necessary as representing little more than that utilized in carrying on the functional activity of the organism. Brain workers have long been known to indulge freely in the use of alkaloidal and alcoholic beverages, preferring the alkaloidal, as it seems better adapted to their purpose.

Appetite. There is every reason to believe that appetite is an acquired quality. It is cultivatable, and from its dictates civilized man, irrespective of dietaries, selects the food upon which he hopes to maintain life. It is largely the result of habit and may be transmitted from one generation to another. No dietary can be considered as desirable where appetite is ignored, and the more successful the efforts to cultivate an appetite in harmony with properly selected scientific food, the greater will be the advances in the treatment of disease, and the maintenance of normal digestive functions. Appetite may be at wide variance with recognized dietetic laws, and such variance not be conducive to the development of disease. Not infrequently it will be wise to follow the dictate of appetite, provided it be formulated upon an intelligent basis and not upon a mere temporary or passing caprice developed from the inner consciousness by some process of suggestion. Appetite demands variety in food, and for this reason the potent elements of each group of foods may be made to alternate with each other without any detriment to the theory involved.

Administration. The time and method of administering food have received consideration from many dietetic writers; each one has seen fit to suggest views evidently in accord with his own feeling in the matter. It seems reasonable to suppose that habit is the most influential factor in determining the intervals between the meals and the time and distribution of the quantities utilized for food. It may be safely said that the more digestible the food, the shorter the intervals should be between the meals. The habits of countries have materially influenced the hours for taking food, as has also to a certain extent the climate; thus, in warmer climates, the mid-day meal, taken during the heated hours of the day, is usually the frugal one, and the evening repast the more generous, while in the temperate regions the reverse holds true. Dr. Edmund Smith recommends as a physiological diet the following, which he distributes in three meals :—

	Carbon, grs.	*Nitrogen, grs.*	*Carbonaceous, ozs.*	*Nitrogenous, ozs.*
For breakfast, . .	1500	70	6.62	1.04
For dinner, . . .	1800	90	7.85	1.34
For supper, . . .	1000	40	4.25	0.59
Total, ...	4300	200	18.99	2 97

Individual tastes and habits must be consulted in considering the distribution of meals, and, independent of fixed and regular hours, hunger, like thirst, is a demand which in the healthy individual is always to be respected, and never allowed to pass into that point known as insatiable. There is every reason to believe that dilated stomachs and digestive troubles are encouraged, even actually produced, by gorging with enormous quantities at regular intervals, in order to maintain the strength during a given length of time.

Cooking. For civilized man, cooking is demanded. The influence which cooking bears upon food can hardly be estimated. Its digestibility, its nutritive equivalent, its potential energy, are all influenced more or less by the process. On the average, foods in the fresh state lose weight by the cooking process, the loss amounting, in some cases to twenty or thirty per cent. The process renders mastication more easily accomplished, and in the majority of cases favors digestion by rendering the disintegration of the food more rapid and complete. This is not, however, always the case, as Beaumont has shown that raw pork digests in three hours, while roast pork will require from five to five and one-half hours. Roast potato may be digested in two hours, while a boiled potato will require three. Scientific cooking is needed nowadays, more than the nicely defined dietaries. The belief that so many grains of nitrogen and so many grains of carbon are all that is necessary is widely at variance with the true condition of affairs.

Meats should always be cooked, by reason of the animal and vegetable parasites which may be present; nothing but efficient cooking insures their destruction. Trichinæ present an example in which cooking must be thorough in order to secure their destruction. If meat shows a blood-red color, it is probable that a temperature of over 135° F. has not been reached, and any degree short of 160° F. cannot be depended upon. Where the possibility of a vegetable parasite is to be met, no temperature short of 212° F. can be relied upon. Abbott has recently presented the dangers arising from washing vegetables in infected waters and then not cooking them ; so that where the water supply is of a suspicious character, or known to be infected, the demands for efficient cooking are accentuated.

Of the animal foods, more particularly the meats, roasting, or its equivalent, broiling, probably represent the best forms of cooking. Boiling, stewing and frying, follow in the order named; the latter, in not a few cases, lessens and retards the digestive process by saturating the meat with oil which is but little, if any, influenced by the gastric juice. The influence of cooking upon the digestibility of vegetables, is not so marked as in animal foods. The palatability of both is greatly increased by the culinary art and appetite sharpened by the addition of seasoning and condiments, not readily introduced after the cooking process.

Digestibility. The importance of this cannot be over-estimated. After a long illness, during an acute febrile attack following a grave surgical operation, after a prolonged march or an exhausting fast, the tide of life may hang upon the rapid and ready assimilation of food. It goes without saying that foods requiring the least mechanical aid in digestion, such as soups, broths, and allied fluids, will most rapidly reach the circulation. In no small number of these cases a stimulant is demanded, in order that its immediate action may bridge over the period necessary for even a brief or partial digestion. The beef, mutton and chicken broths, and teas fill the requirement more or less completely. Milk to which we would immediately turn, while fluid before ingestion, soon becomes a solid in the stomach. That this can be partially overcome by peptonizing is admitted, and if so prepared it becomes an efficient emergency food. Hot foods assimilate with far greater rapidity than cold, and, where the patient's selection permits, are to be preferred. Milk whey, wine whey, bouillon, dilutions of concentrated foods, such as meat extracts of reputable makers, are quickly acting stimulants and foods. Next to these and similar preparations come the farinaceous aqueous solutions or suspended foods, both starchy and saccharin. Barley, gruel, arrowroot, oatmeal, mixed with the liquid animal foods enumerated above and the mixture afterwards strained, afford readily prepared emergency foods. Koumys, kefir, and similar preparations can be utilized.

Idiosyncrasy. There can be no doubt that idiosyncrasy plays an important part in individual cases, and no small number of cases will be found in which many foods considered readily digestible are not so, and *vice versâ.* Under this head we also include the temperaments, tissue peculiarities, which we identify as the gouty and rheumatic, nervous or irritable, etc., each group requiring a variation in food which its members use. The unexpected effect at times produced by some foods are explainable only by this peculiar cryptogenic principle. Diarrhea due to eating fruit, gastritis following a meal containing cabbage, enteralgia induced by coffee, are examples illustrating that unexplainable factor, personal idiosyncrasy.

Quantity. The quantity of food demanded by the organism may be calculated either upon the amount of work done or upon the excretions as already stated, work done being estimated in foot tons, that is, the force demanded to raise one ton through a given number of feet or to raise a given number of tons through one foot, the one being equivalent to the other.* A certain quantity of force is demanded to carry on functions of organic life, such as respiration, circulation, digestion, etc. If these could be accurately estimated, much less difficulty would be found in formulating dietaries, but our knowledge of the demanded quantities of force utilized in the vital processes is largely theoretical. It is presumed that about 2500 foot tons are required. To make up for loss in radiation and by other means, it is estimated that only about one-fifth of the food force over and above that used by the economy is available for work, and hence, in order to obtain a given number of foot tons, at least five times the number of foot tons must be supplied in the food. Thus to furnish 400 foot tons of actual work over and above the vital processes, about 2600 foot tons must be allowed

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* In mechanics the force demanded to raise one ton one foot is known as a *foot-ton.*

for organic life and 2000 foot tons for the labor desired, 1600 foot tons being demanded above the quantity which will be productive as work. The individual capacity for converting food into work will vary within wide limits, a well developed strong man, under favorable circumstances, being able to accomplish about 600 foot tons, although for continuous work he will rarely be able to exceed 437 foot tons per diem. Given the number of foot tons desired and calculating the productive work with the allowed surplusage demanded, as given above, the groups of food as already given may be calculated to afford about as follows: 1 ounce of proteids (dry) 173 foot tons; 1 ounce of fat, 378 foot tons; 1 ounce of sugar or starch, 135 foot tons.

While the above may be considered as affording a fairly reliable clue, it cannot be regarded as in any way directing an accurate estimate. Besides, from the calculations alone no proportion of ingredients is given. It has been demonstrated over and over again that a diet selected from one food group alone does not meet the requirements of nature, and that under such circumstances an excess of one element must be administered in order to approach the demanded supply of another. In order to meet this objection, recourse is had to a study of excretion, and calculation made to supply a quantity of food through which the processes of combustion and oxidation will replace the elements found in the excreta. Heat, force, and function are but expressions of combustion, the food supplying the elements from which all are elaborated.

In the excreta will be found 300 grs. of nitrogen and 4600 grs. of carbon per diem, a proportion of about 1 of nitrogen to 15 of carbon. It would therefore appear, theoretically, that food must be supplied upon the basis of 1 of nitrogen to 15 of carbon, to replace those elements lost. Not only has this ratio been presumed to be advantageous, but practical dietaries have demonstrated its utility.

If the selection of food was made purely from the albuminates, *e.g.*, meat, 46,000 grs. would afford 4600 grs. of carbon and 1380 grs. of nitrogen, a proportion of three parts of carbon to one of nitrogen. Again, if the food be selected from the carbonaceous groups, an excess of carbon will be present equal to, if not exceeding, 30 parts of carbon to 1 of nitrogen. It is, therefore, demanded that diet shall be mixed; the following affording an example:—

	Grains.	*Grains.*
About 2 lbs. of bread contain	C 4630	N 145
" ¾ lbs. of meat contain	C 463	N 154
" 2¾ lbs. of bread-meat contain	C 5093	N 308
or	C 15	N 1

With these proportions borne in mind we have but to apply the knowledge of force demanded in order to calculate food-tables or dietaries. Thus, Wilson gives, as estimated by Moleschott, Playfair, Pettenkofer, Parkes, and others, the following:—

WATER-FREE SUBSTANCES GIVEN DAILY.	SUBSISTENCE.	ORDINARY LABOR.	ACTIVE LABOR.
	Ounces Avoir.	Ounces Avoir.	Ounces Avoir.
Albuminates, ...	2.0	4.5	6.5
Fats, ...	0.5	3.5	4.0
Carbohydrates, ...	12.0	14.0	17.0
Salts, ...	0.5	1.0	1.3
Total water free foods, ...	15.0	23.0	28.8

It is probable that as we approach active exercise or work the percentage of carbon should be slightly increased. This is partly allowed for in the above by the fats in ordinary and in active labor diets, being respectively 6.5 and 8 times the quantity given for a subsistence diet.

CHAPTER V.

WATER.

Water is one of the most essential elements demanded by the system for the maintenance of life. Chemically pure, it is composed of two elements, hydrogen and oxygen. From natural sources chemically pure water is never obtained in sufficient quantities for public use.

Source. While the source of water is an object of some importance, it is not often a matter which the sanitarian can direct; it is usually obtained from one of the following sources:—

Rain Water. Rain water is collected, as a rule, from roofs and, on board ships, from sails spread expressly for the purpose. It is a soft water, and while at first it would appear that rain water must be pure, such is not always the case. In its descent it may have absorbed gases or carried down suspended particles, both organic and inorganic, in sufficient quantities to render it impure. This is more particularly the case in manufacturing and very populous districts. Impurities are also largely collected from roofs in the shape of dissolved metals; hence the advantage of slate roofing; the excreta of birds, soot and dust, vegetable spores, plant life in all its forms, including bacteria, may thus find entrance. Thus it will be seen that where it is desirable to use rain water from roofs, the first gush of water should be rejected, after which a fairly potable water may be obtained.

For estimating the quantity of rain water from a given roof, it will be necessary to know the annual rain precipitation and the area of collecting surface. In the case of houses this can be easily calculated by measuring the exterior walls, as the roof pitch does not influence the collecting area. Given these two points, the amount of water supplied may be readily calculated; if the area of the collecting surface in square feet be multiplied by one-half the rainfall in inches, the result will give the amount of water in gallons with an error of about four per cent.

Rain water is usually stored in cisterns or tanks composed of some impermeable and insoluble material, for example, slate, masonry, cemented brick, or concrete; slate probably affords the best cistern. Iron and galvanized iron containing no lead may be used for storage purposes. Lead and galvanized iron containing lead should not be used. Wood, either plain, charred, or pitched, is to be rejected, as sooner or later it becomes a source of infection. Cisterns or tanks should be above ground, never under; if it be imperative to place the cistern under ground by reason of excessively cold winters which freeze surface cisterns, the container should be constructed of masonry or cement.

Spring Water. Where the spring can be tapped immediately at its source, it undoubtedly affords water of a high standard of purity. The danger, however, from pollution is always imminent, for, as usually arranged, springs afford ample opportunity for the ingress of surface water.

For measuring the output of a spring, the best results will be obtained by receiving the water in a vessel of known capacity, which may be ascertained, of course, by measuring with a standard measure, or with the capacity of the vessel in cubic feet, it may be brought to gallons by multiplying by 7.48. By noting the flow during a given time, the output for twenty-four hours may be readily estimated. Should the spring be a tidal spring, two measurements will be necessary, one when the flow is least and another at the maximum, the calculation being based on the mean flow as estimated from the two observations.

Surface water includes river water, the upland water of the English writer, and shallow well water; the latter will be apparent when we remember that as much as eight or ten feet of the earth's crust drain, in most localities, the entire surface water. Surface water is, in the large majority of cases, highly polluted, and especially is this true where it is collected from areas having abundant habitations. In rivers utilized to supply towns and cities, when they receive sewage and manufacturing refuse, the contamination of the water varies to the extent of the materials which may be allowed to mix with it. The idea that water purifies itself by oxidation is true to a limited extent, but where the impurity is a pathogenic organism, the effect of oxidation cannot be assuring, and water receiving infected sewerage remains infected, but little altered except by dilution and the temporary effects of sedimentation.

In estimating the water output of a stream where it is possible, engineers use the weir gauge. The weir gauge consists of a plank set on edge and maintained perfectly level by means of a plumb line or spirit level. In this plank, a rectangular notch one foot in width is cut, and the difference of level above and below the weir may be estimated by measuring the depth of the water which is flowing over the notch, and from a given table the calculations estimated.*

A very convenient method for measuring the supply of water from an ordinary stream consists in obtaining the surface velocity by throwing a chip or suitable material on the surface at some point where the current is constant and not affected by winds at the time of the experiment, and noting the length of time which it requires for this fragment to pass over a given space. This will give the surface velocity; multiply four-fifths of this, the approximate stream velocity, by the sectional area; the result will be the yield in cubic feet per second, presuming, of course, that the initial surface velocity be reduced to a second as the unit. Cubic feet may be reduced to gallons by multiplying by 7.48. If the quantity of water be not too large, it may be conducted through a trough of known dimensions, and by obtaining the velocity, the output may be readily calculated.

Well Water. This includes deep wells, driven or bored wells, and artesian wells; the shallow well water is to be regarded as surface water. Wells sufficiently deep to pass through an impervious stratum to a water-bearing stratum below, or wells cemented to a point below the possible entrance of surface

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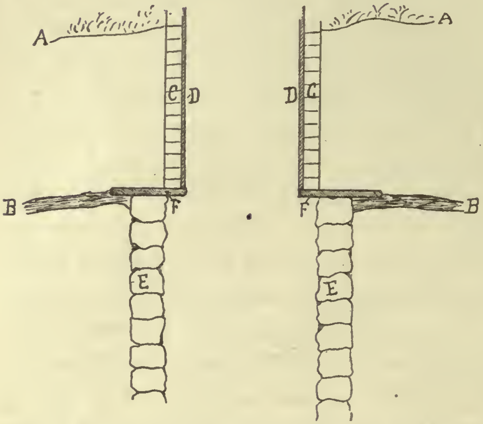
* *Discharge of Water Over a Weir One Foot in Length.* If the weir is more or less than one foot, multiply the quantity in the table opposite the given depth by the length of the weir in feet or decimals of a foot. Thus, if the weir measures one foot, and the depth of the water falling over be two inches, the delivery is read at once, viz., 13.63 cubic feet, or 84.9 gallons per minute. (Imp. Gal.).

Depth falling over, inches.	*Discharge per minute.*	*Depth falling over, inches.*	*Discharge per minute.*
½	1.70 cub. ft.	2 ½	19.70 cub. ft.
1	4.82 " "	3	26.62 " "
1 ½	8.84 " "	3 ½	33.22 " "
2	13.63 " "	4	40.71 " "

—"*Sixth Report of the River Pollution Commission.*"

water, afford an undoubtedly pure water from a sanitary point, provided they do not contain sufficient saline or other inorganic principles to render them injurious. This objection has been found to hold more constantly with artesian wells and occasionally in driven wells, rarely with deep wells, unless they should be in an area containing large quantities of saltpeter, chlorid of sodium or other salines in the deeper stratum of the earth.

Fig. 52.



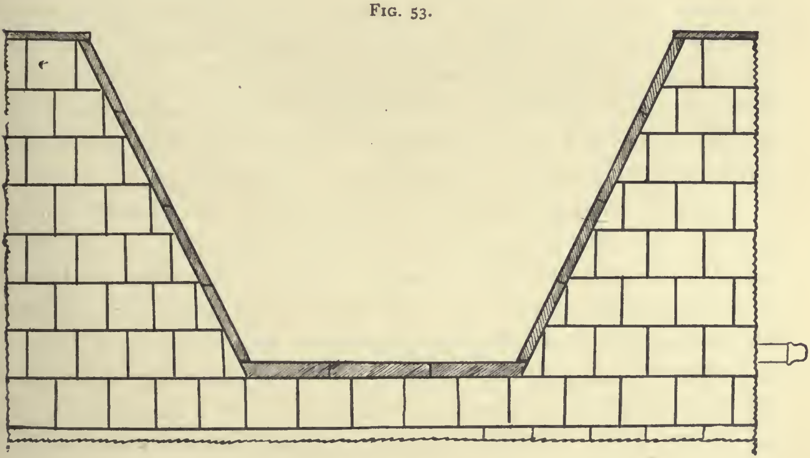
Plan of Deep Well. A. Ground surface. B. First impervious stratum. C. Brick wall. D. Cement lining. E. Rough stone wall. F. Flagstone between the brick and stone walls with cemented joint immediately over F.

The rate of production from a well may be estimated by pumping out the water and measuring it either with an automatic pump or through casks of known capacity, and then noting the time required to fill. In deep, driven, or bored wells, the inflow may be estimated by the exhaustion process in which constant pumping is kept up until no more water can be obtained; then, at the end of a time varying from one-half to two or three hours, or longer, the pumping is resumed and continued until the well is again exhausted; it may thus be estimated what the supply of water has been in the time since the previous exhaustion. Allowance must be calculated for rate of filling during the time of pumping.

Storage of Water. In public water supplies there should always be abundant and capacious facilities for storage. These not only afford opportunities for laying by a supply for two or three days, but also to act as subsiding reservoirs for the removal of such suspended matters as will separate by subsidence. Occasionally natural, sometimes artificial lakes, but more commonly reservoirs, are used for storage. Facilities should be afforded for emptying and cleansing the reservoir from time to time. Where large natural lakes are depended upon, the pollution of the water during storage should be guarded against in every possible manner. In large cities three or four subsiding reservoirs are necessary, representing sufficient water supply to permit at least three days' (preferably a week) subsidence before the water is drawn off for use. Efficient flushing facilities must be secured for washing out the reservoir after each emptying, and the number of subsiding reservoirs should be in excess of the actual demand.

Distribution. Water is usually distributed in cities through a system of iron pipes. Lead pipes, or lead pipes lined with tin, have been used but have proven objectionable. Iron pipes glazed or vitrified by a glass lining have been manufactured to displace iron. It would seem, however, that the lining of pipes affords false security, as the lining cracks and fissures, and where pipes are lined with tin, it has been found that these cracks form a galvanic couplet which rapidly leads to the reduction of the lead used commonly in the sealing of joints.

FIG. 53.



MODEL OF RESERVOIR (ON SECTION) SHOWING MASONRY WALLS OR BRICK AND CEMENTED SLATE LINING. THE BEST FORM OF RESERVOIR.

Methods of Distribution. Two methods of distribution are known, the *Constant* and the *Intermittent.* The latter demands storage in the house as well as public storage, and is to be strongly condemned.

The *Constant* is more in use and affords the least objections. It has been maintained that the *Intermittent* is less expensive, but it is not probable that if as much water is used, there would be any observable difference between the cost of the two systems. In the Intermittent system the water supply is made in different areas of the city at different hours and each area must store up water in sufficient quantities to last until another supply is furnished. The objections to this demand lie in the fact that house storage is necessary, and this brings with it all the dangers of unclean, badly ventilated, improper receptacles in houses. The most rigid inspection is demanded where this system is in vogue, and even under the most careful scrutiny negligence, at times, offers ample opportunity for contamination and the spread of disease. The Constant system is the one more available, and is not, of necessity, more wasteful than the Intermittent, and certainly is much safer to public health.

Quantity Demanded. In estimating the water supply for a city or town, the population is usually taken as a basis upon which such estimations are made. For individual use, including water for cooking, washing, baths, etc., a supply of from sixteen to twenty gallons per day is necessary. Where there are manufactories, from ten to fifteen gallons per head must be added to the necessary amount for household purposes. It will thus be seen that a wide range of water supply must be taken, as demanded in individual cases. London and Glasgow vary in their estimated water supply, the former having forty and the latter fifty gallons per head, per day. It has been estimated that for horses ten gallons should be allowed, for a cow eight gallons, for the sheep and pig about one gallon each. Where street-flushing and sprinkling is enforced, an additional allowance of two gallons per square yard must be made; but as flushing and sprinkling may be intermittently applied over the city, the calculations need be based upon a small area only.

Dangers Arising from Deficient Water Supply. As far as the sanitarian is concerned deficient water supply never reaches that point amounting to water starvation. It is almost exclusively what is popularly known in the cities as a " water famine," or scarcity of water. The dangers arising from deficient water supply are, for the most part, those associated with want of cleanliness. Applied to a community at large, the effects due to accumulated material in sewers and the collection of dirt in the street are most prominent. These factors lead to the spread of very many diseases, notably, typhoid fever, typhus fever, and diphtheria, the latter being certain to develop where the individuals are crowded together in large tenement houses or in the dirtier streets and alleys which, at best, are poorly cleaned and badly ventilated. It is also to be remembered that when a deficient water supply is due to a drought, any contamination in the water will be proportionately increased, while if the deficiency is due to other causes, for example, the rupture of a reservoir or the diverting of the water from its usual course, accidental causes, such dangers are less likely to arise. It is usually after a water famine, that disease is most prone to manifest itself. This may be only apparent as the period of incubation lasts for several days, even weeks in some diseases, thereby permitting the disease to run a considerable time after the cause has gained entrance to the system before it breaks forth. Another fallacy in these observations is the fact that drought or water famines usually terminate by an abundant supply of surface water, distributed without any sufficient preliminary purification, thus carrying accumulated infective matter directly into the system of distribution throughout a city, and in this manner scattering infection broadcast.

Impure Water Supply. Hardness of water is due to the presence of earthy salts, carbonates of lime, and magnesia, producing temporary hardness; and sulphates of lime and magnesia, intermixed with carbonic acid salts producing permanent hardness; occasionally the water will contain sufficient chlorid of sodium to give it a distinctly saline taste. In mining districts chromium salts may be present, although rarely in sufficient quantities to give rise to any disease; they are to be considered as injurious, and the water is to be rejected when they are present to any marked degree. Iron may be present in water, although rarely in sufficient quantities to give rise to any interference with the public health; it is one of the most readily tasted impurities and is therefore easily detected. Sulphur and sulphurous acid compounds are found for the most part in the water of medicinal springs and rarely are brought forward as causes of disease.

The most important impurities in water from a sanitary view are the organic constituents, animal and vegetable. These include sewerage, all forms of decomposing vegetable material, and animal matter, bacteria and their products. These organic impurities will be chiefly reviewed when considering diseases attributed to impure water.

Diseases due to Impure Water. Affections of the alimentary canal, including dyspepsia, diarrhea and dysentery, may be in a large number of cases due to impure water. It has long been known that water containing sewerage acts as a prolific cause of diarrhea and dysentery. Whether this be due to suspended organic matter, parasites, animal or vegetable, bacteria or their products, is still a matter of dispute; it is, however, probable that microbic poisons may be considered as the most active. Sulphuretted hydrogen, and suspended vegetable matter other than bacteria, have been supposed to give rise to diarrhea. Hard water has been supposed to give rise to disturbances of digestion, renal calculi, and anemia, but sufficient evidence is wanting.

Cholera and *typhoid fever* are probably the best examples of, and the most common, diseases transmitted through an infected water supply. Epidemic after epidemic has demonstrated in the clearest possible manner the relation existing between typhoid fever, cholera, and infected water supplies. Scientific men are now agreed that this spread is dependent upon the transmission of the specific microbes of the two diseases. Based upon our knowledge, therefore, of typhoid fever and cholera, we may assume that any of the diseases due to microbes may be spread through the medium of infected water. This has been demonstrated as probably occurring in diphtheria and scarlet fever, but the complexus of circumstances surrounding such observations is such as to render proof uncertain or unsatisfactory.

The spread of *malaria* has been traced directly to the water supply. Probably the most conclusive evidence that we have in this direction is that recorded by Boudin. Three vessels sailed from Bona in Algiers to Marseilles, all carrying soldiers; at the time of sailing the passengers were all in the most excellent health; during the voyage, however, upon one of the vessels thirteen men died; and of the 107 survivors, 93 disembarked suffering from malarial fever. On the other vessel there were 680 men, none of whom were sick. The explanation of the sickness of the men upon the first vessel is founded on the fact that the water supplied was from a marsh in a malarial area, while the water upon the other vessels had been supplied from an unpolluted source. This is but one example of the numerous instances that are now on record where malaria has been intimately associated with the supply of water obtained from marshy lowlands and infected areas. Believing, as we do, in the specific cause of malaria, such facts are entirely in harmony with the accepted views of its etiology, and in accord with the views already advanced of the spread of typhoid fever and cholera.

Goiter, *cystic calculi*, *boils*, etc., have been supposed to be due to impurities in the water, the most acceptable theories tracing them to variations in hardness and to organic constituents. Such theories are, in the present state of our knowledge, to be considered as apocryphal.

Of all the *parasitic diseases* named in the chapter on the causes of diseases it is highly probable that water may be the carrier of the infecting parasite. Where the parasites live within the body their ingress is usually secured through the alimentary canal, while those having their habitat on or in the skin and its appendices usually gain ingress during bathing or exposure to the water.

In *yellow fever* there is a possibility of water carrying the poison, although sufficient evidence has not been adduced to establish any facts.

Ptomaïne poisoning may arise from the ingestion of water containing large quantities of sewerage; cases of this kind have been observed in youths bathing near the exit of a sewer into a stream, and whether they swallowed the water or whether it can be absorbed through the cutaneous surface is still a matter of dispute.

Parkes suggests the possibility of the bronchial and urinary mucous membranes being affected by impure water, but there is little evidence to support such a theory.

The production of *metallic poisoning* in its chronic forms is extremely likely to occur from the use of water containing poisonous metals in solution.

Aside from the specific diseases which have already been referred to, one is to remember that as water is an important factor in maintaining the nutrition of the body, anything which vitiates it must of necessity affect the health of the community in a direct ratio to the degree of impurity.

The Purification of Water. This is to be accomplished on a large scale at the point of storage, in the minor details at the point of distribution, that is, in the houses of those using the water.

For purification on a large scale, we are to depend for the most part upon physical and mechanical means, including *subsidence* and *filtration.* In cities where subsidence is depended upon for attaining purification, large reservoirs should be constructed, permitting the storage of several days' supply, which should be allowed to subside for at lease three, preferably five to seven days, or even longer, before it is drawn off, and care should be taken to tap the water at such a point as not to remove the sediment by the first current induced. After each emptying the reservoir should have a thorough cleaning.

Purification by filtration is usually accomplished through a bed of sand, gravel, charcoal, spongy iron, or coke of various depths. Mixed processes of filtration depend for their efficiency upon the addition of some chemical to the water before it is filtered. This is usually alum ; if carbonate of calcium be present in the water, sulphate of calcium is formed with a flocculent precipitate of aluminum hydrate entangling any suspended matter, which may then be removed by filtration.

The essential elements of a filter on a large scale are, first, it must be effective, second, it must be rapid, and third, there must be facilities for renewing that portion of the filter which receives the suspended matter from the water, in other words, it must be so arranged that the entire filtering apparatus can be cleaned from time to time. Unless such arrangements are made and carried out, the filtering cannot be efficient. The popular idea that placing a filter in position will forever render the water pure is the greatest possible mistake. Organic matter lodged in the filter affords a culture media for bacteria, many of them pathogenic, and renders the filter a veritable hotbed of disease. Not only should the entire filtering apparatus be cleaned from time to time, but if sand is used for the filter, the upper layers should be renewed as soon as any considerable dirt is discerned.

A sand or gravel filter bed to be efficient must be made up of sand or gravel free from loam or clay and possessing but little cohesion between the grains. Such a sand cannot be held in the hand in running water, as it will creep through the fingers. The bed should be not less than 15 inches in depth and the inflow of water so arranged as to preclude the constant stirring of the sand. The efficiency of the sand filter is enhanced by the deposition on its surface of a thin layer of mud, and the thicker the layer the more efficient the filter, until at last filtration will be arrested. While the accumulated mud increases the efficiency of the filter, it may at times endanger the output, especially if it contains an excess of organic matter; hence leaves and decaying vegetable matter in such a bed must be looked upon with suspicion, if not, indeed, regarded as positively dangerous. A system of filtration has been recently devised by means of which a reflux of filtered water may be secured, and

FIG. 54.

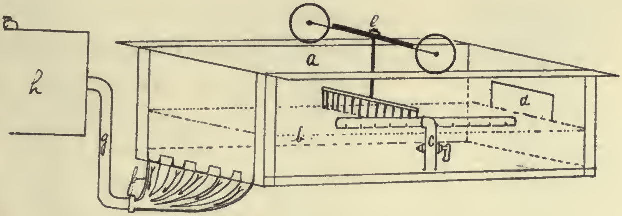
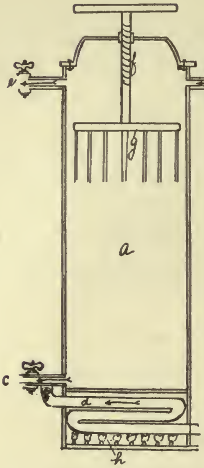


DIAGRAM OF FILTER FOR PUBLIC WATER SUPPLY.

a. Receiving tank or reservoir. *d*. Flush gate for same. *b*. Sand bed, to be made up of successive layers of sand of varying size grains, the larger quartz at bottom. *c*. Entry pipe carried out laterally to secure influx at a low velocity. At *c* is shown cock for controlling supply. *f*. Shows line of conduits to chamber, *h*, through pipe, *g*. To start the filter, the receiving tank *a* is first filled; chamber, *h*, is then filled with unfiltered water and syphonage established into the general water system to be supplied. To wash the filter, turn off the supply at *c*, open gate, *d*, and then the air-tight manhole in chamber, *h*. This permits a reflux of filtered water. The rake, *e*, is moved backward and forward on the tracks as shown by the wheels; this stirs the superficial layer of sand, and the dirt is carried off by the refluent at *d*.

if the surface bed of mud be stirred during the flow of the refluent the surface of the filter may be thoroughly cleansed and the deposited super-stratum carried off through a wash-gate arranged at the side or end of the filter bed. This system presents a point of economy in that it does not require renewal of the sand. The same principle has been applied in domestic filters, and it has been here strengthened by securing ingress of the refluent heated, the supply either coming from the hot-water system of the house or heated through a coil and burner beneath the filter as it enters at the bottom. A device is secured in the top of the filter bed for stirring the deposited mud and a superficial layer of the sand while the returning hot-water current is flowing.

Fig. 55.



Large Domestic Filter Constructed on the Same Basis as Filter shown in Fig. 54.

a, sand chamber; *b*, inlet from street supply; *c*, normal outlet to house. To wash out and disinfect this filter, turn off water at *b* and *c*; open cock at *e*, then admit water from hot-water pipes, through *d* at the bottom, at the same time agitating the sand by means of the screw, *f*, acting on the rake, *g*. In case hot water cannot be had from the house supply the refluent may be heated by means of gas or oil applied under a coil, as shown at *h*.

It would seem from the opinion of some experts, who have gone into the matter more or less fully, that intermittent filtration affords a method for securing cleanliness of filters, bacteria destroying the organic matter in the filter during the intervals in which it is not in use. This apparent cleansing of the filter seems to us extremely faulty, for there can be no doubt that some disease germs might lie in an open filter for a prolonged period and still retain their activity. Theoretically, therefore, there are urgent objections to such methods of filtration.

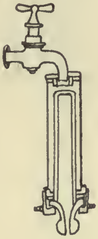
The two or three methods, devised by different inventors for the purification of water after the addition of alum, have been found extremely useful and efficient in the cities of the South and West, where the water is very muddy and loaded with other suspended matters.

Domestic Filtration. There can be no doubt that the proper filtration of water in houses is always to be commended. The great source of error lies in the fact that it is almost impossible to get a family to keep a filter clean; therefore, an essential element in an efficient domestic filter is *simplicity;* all of the parts should be so arranged that they can be readily cleansed and disinfected. All filters having solid chambers which cannot be removed for the renewing of the sand or other material used for the extraction of impurities are to be rejected on the ground of deficiency in ability to clean. Although the market is loaded with domestic filters, there are very few deserving of public confidence. Probably the best form of domestic filter is that based upon the filtration through a layer of unglazed porcelain, porous stone, a porous sand composition, or, possibly, spongy iron. These all allow of being placed in the oven and baked without injury, and may be thus cleaned. The filter should be thoroughly washed at least once or twice a week and then baked in the oven or "fired." "Firing" a filter consists in saturating the filter with alcohol and then setting the alcohol ablaze; this should be accomplished from underneath, so that the heat may ascend through the filter and destroy any bacteria which may be present. Vegetable charcoal and sponges are to be condemned upon the ground that it is necessary to destroy them in order to secure disinfection; the fact that their destruction demands, each time, a small outlay of money and some labor

Fig. 56 A.

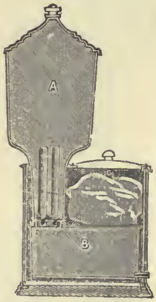
A Pasteur-Chamberland Filter Attached to Spigot.

Fig. 56 B.



Sectional view of 56, A, showing relation of parts with filtering "bougie" in position.

Fig. 57.

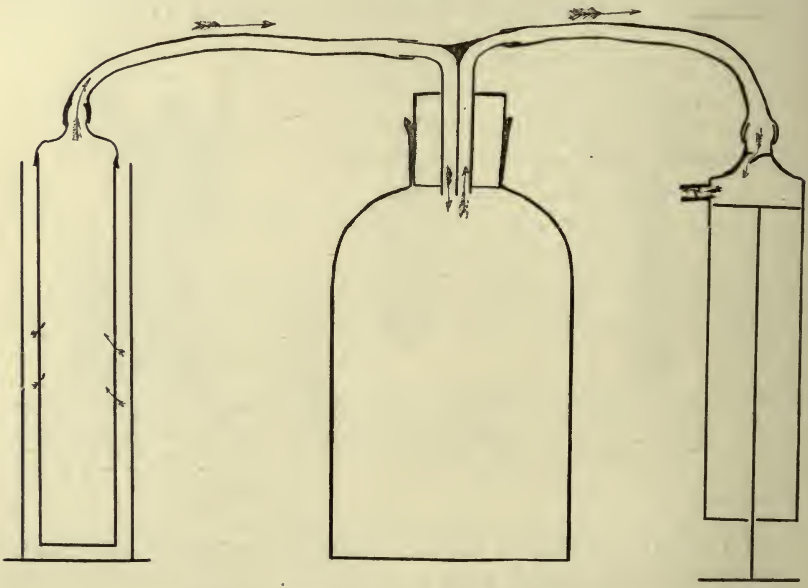


Form of Pasteur Filter, showing filtering tubes in position, also side tank for ice so arranged that the water from the melted ice does not mix with the filtered water.

will make families negligent and careless; indeed, the writers have known of filters that ran one and two years without cleaning, only to terminate with an epidemic of typhoid fever in the house; then, of course, the filter was blamed and not the residents of the house. There can be no doubt but what this occurs over and over again, and it is to be guarded against in the recommendation of domestic filters.

No matter what may be the form or process of filtration, water should always be boiled before it is used. Boiling insures the destruction of any bacteria which may be present, and there is no possible excuse for the use of unboiled water when there exists any reason for discrediting the purity of the supply. Even the use of ice water, water produced by the melting of ice, is not

FIG. 58.



PASTEUR-CHAMBERLAND FILTER, TOURIST PATTERN.

This can be conveniently packed and carried by the traveler who wishes to filter all drinking water. The cylinder on the left contains the filter "bougie," which may be scrubbed, boiled, or baked as often as necessary. To use this filter the different parts are connected by rubber tubing as shown in the drawing. The quart bottle in the center is then exhausted of air by means of the pump on the right, the "bougie," shown on the left is then immersed in the water to be filtered. As the water contains some gas the vacuum in the bottle will require re-exhaustion from time to time. The arrows passing toward the bottle indicate the direction taken by the water, those from the bottle to the pump show the track taken by the exhausted air.

to be recommended without a most thorough boiling. Prudden, of New York, has demonstrated the presence of typhoid fever bacilli in ice, and as no ice company can be made to insure the quality of this commodity, it will be much better and safer to always boil the water and secure its cooling in a suitable receptacle excluded from the melted ice.

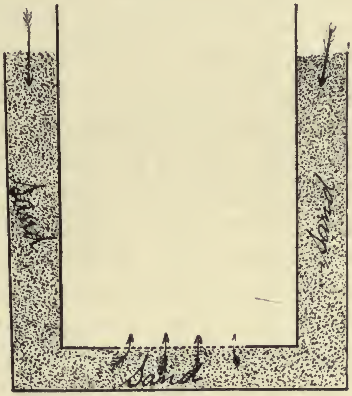
The *distillation* of water as a process of purification is to be considered only when on board ships and where it is not to be used in large quantities. In order to have pure distilled water, first, the water must contain no gases which may be brought over with the distillate ; second, the water should be boiled thoroughly before the distillation begins and the first steam allowed to escape without gaining ingress to the condensing apparatus ; third, the entire apparatus should be made out of block-tin or such other material as will not yield any poisonous metal to the water during the process of distillation. In order to render such water palatable aëration is demanded.

FIG. 59.

SIMPLE FILTER.

Consisting of an ordinary percolator, two layers of cotton with a layer of quartz between, and an inverted glass funnel resting upon the upper layer of cotton which it retains in position. This simple apparatus may be constructed of almost any substitute for the percolator here shown. If before filtration alum be added to the water, in the proportion of 2 grains to the gallon, a very clear product may be obtained.

FIG. 60.



SAND FILTER.

(The arrows indicate the direction of the flow of water). It is intended that this filter may be made of two sizes of cans with sand between them. The inner can is perforated at the bottom. To use this improvised filter it may be sunken to the top of the outer can in water or water saturated soil. It can be disinfected by boiling and can be refilled by troops at their convenience, being disinfected before use. For its manufacture take two sizes of the ordinary fruit cans, such as are supplied soldiers or two sizes of tanks or hogsheads, in fact any two water-tight vessels, the inner one having perporations at the bottom. To prevent the sand arising in the inner can a layer of cotton or a muslin cloth between the bottom and the sand may be found useful. The writers have frequently tested the efficiency of such a filter.

Water Examination.

Collection. The method employed in collecting a sample of water is apt to greatly influence the result of a chemical or biological analysis, therefore, great care must be exercised and certain rules followed. The vessel in which the water is to be collected, if intended for chemical analysis, should be a glass bottle provided with a glass stopper, and of a capacity of from two to three pints. The bottle must be scrupulously clean. Two precautions must always be observed: 1st. The bottle is rinsed with water from the same source as that from which the sample is to be taken, and immediately before collecting the water intended for analysis. 2d. If the sample is to be taken from a stream or pond, the bottle should be submerged about one and a half feet below the surface, so as to avoid surface contamination; if from a pump or hydrant, several gallons of the water must be allowed to flow away, so as to obtain a sample direct from the well or main. The bottle should bear a label, upon which is legibly written the date on which the sample was taken—whether from a well, deep or shallow, pond, reservoir, stream, or from the main of a public supply; the environment, that is, the propinquity of middens, cesspools, drains, sewers, stables, farms, etc.; also, if from a pump or hydrant, of what material the pipes are constructed.

In collecting water—and the same applies to sewage, etc., for a biological examination—great care must be exercised to exclude extraneous organisms. The bottle, flask, or whatever the collecting vessel may be, is washed perfectly clean, plugged with cotton, and sterilized in the hot-air sterilizer. Sternberg's bulbs are very convenient for collecting water, especially if it is intended to be shipped any distance. If the water has to be transported, or if it is impossible to examine the specimen immediately, it should be packed in ice, to prevent the rapid pullulation of the organisms that would otherwise occur and vitiate the results of the analysis. The body of water from which the samples are to be obtained, being of easy access and shallow, it is withdrawn by a sterile pipette and quickly deposited in the vessel prepared for its reception. If the water is deep, it will be necessary to procure samples at different depths. To accomplish this, a sterile flask is inverted and attached to a long pole; it is now lowered to the desired depth and the flask righted; when filled, which will be indicated by the cessation of bubbles rising to the surface, it is drawn up, and the contents placed without delay in other sterile flasks. From a sanitary point of view, while the number of organisms in a specimen are significant, and an approximate quantitative analysis important, a qualitative analysis is decidedly of more moment. Plating is the method upon which the accuracy of our investigations will mainly depend—and fractional plating should in all cases be resorted to.

In our examination of water and other fluids, test-tube plating has proven very satisfactory; so also has the bottle plating, recommended by Leffmann and Beam, and described under plating. (See *Technic.*)

While the *odor*, *color*, and *transparency* of water are not absolute tests as to its potability, yet they have considerable value, and observations on these points should never be neglected.

Odors. Waters from which unpleasant odors emanate are almost without exception non-potable. The odor may be determined by pouring into a narrow-necked flask sufficient water to make it one-third full, and then vigorously shaking the flask; if no odor can be detected, heat the water and again shake; if it still gives off no odor, add a small piece of caustic potash. The waters from some of our mineral springs have a very disagreeable odor, but this odor is due to the presence of hydrogen sulphid, which is occasionally produced in the breaking up of the sulphur compound derived from the soil by certain non-pathogenic microbes.

Color and *transparency* are tested by selecting two tubes of colorless glass, about two feet in length. One tube is filled with the water undergoing examination and the other tube with distilled water for comparison. Hold the tubes side by side over a white surface, and note the difference between them. A yellowish or greenish tint is very suspicious and usually indicates organic matter, though it may be due to mineral salts. A brownish tint is imparted to water by clay, peat, or vegetable matter.

A very simple test which may indicate the presence of sewage is made by introducing into a quart bottle, until it is three-quarters full, the water to be tested, and adding about a drachm of granulated sugar. Stopper the bottle and place it in a warm place for two days, at the expiration of which time the water, if it contains sewage, will appear turbid. Little dependence is to be placed upon this test except as corroborating other evidence.

Total Solids. In good potable waters the total solids should not exceed .06 per cent., though if they be present in a much greater proportion it does not positively indicate that the water is unsuitable for drinking purposes. To determine the total solids, evaporate to dryness in a platinum dish over a water bath a definite quantity of water. Weigh the dish, then wipe it perfectly clean, and again weigh; the difference will represent the number of grains in the water tested. To determine the grains in 100,000 parts, multiply the number of grains in the sample tested by one hundred, and divide the result by the number of c.c. of water tested.

Organic Matter. The determination of organic matter is very easy and simple, but to say that it is or that it is not innocuous is impossible. The permanganate of potash test is accomplished by boiling 5 c.c. of a ten per cent. solution of sulphuric acid with 250 c.c. of water for one-half an hour to remove the nitrous acid. Set aside until the temperature of the water falls to 60° F., and then add sufficient of a solution of permanganate of potash, made by adding 395 milligrams of the salt to one liter of water, to impart a pink color to the water for ten minutes. The number of c.c. of the permanganate solution decomposed represents in one-tenth milligrams the oxygen that has entered into the combination with the organic matter.

Chlorin. If natural sources be excluded, chlorin in any considerable quantity indicates sewage pollution, and if the test for organic matter has given positive results the water should be unhesitatingly condemned. Chlorin may be detected and the quantity estimated by the following methods: Should the preliminary examination develop the chlorin present in small quantities, 250 c.c. are evaporated to 50 c.c., but should it be present in abundance this will not be necessary. The water should be neutral in reaction. If acid, neutralize with precipitated carbonate of calcium. Pour the water into a porcelain dish and add a few drops of a potassium chromate solution, made by dissolving five grams of potassium chromate in 100 c.c. of distilled water. From a burette supply such a quantity of a standard silver nitrate solution (5 grams of pure recrystallized nitrate of silver to 1000 c.c. of distilled water) as will permanently impart to the water a faint red color, through the formation of the chromate of silver. The proportion of chlorin is estimated upon the number of c.c. of the silver solution employed, as every cubic centimeter of the solution used represents one milligram of chlorin.

Ammonium Compounds. The decomposition of nitrogenous organic compounds results in the formation of ammonia nitrates and nitrites, and it is upon the estimation of these that the amount of decomposed organic matter is determined. Ammonia is also produced from albuminous and other cognate compounds by boiling with an alkaline solution of potassium permanganate. To estimate the ammonia it will require the following solutions :—

Sodium Carbonate. Fifty grams of pure sodium carbonate are heated and then dissolved in 250 c.c. of distilled water. Boil the solution until the bulk is reduced to 200 c.c.

Pure Distilled Water. Distilled water, which gives a brownish coloration with Nessler's reagent, contains ammonia from which it must be freed; this may be accomplished by adding one grain of sodium carbonate to each liter of water and boiling the water until it is reduced to three-fourths of its original bulk. By distilling water slightly acidulated with sulphuric acid, water free from ammonia may be obtained.

Ammonium Chlorid. Dissolve 0.382 gram of the pure and dry salt in 100 c.c. of distilled water free from all traces of ammonium. When required for use, dilute one c.c. of this solution with 99 c.c. of pure distilled water. In the latter solution there are .00001 gram of nitrogen in each c.c.

Nessler's Reagent. (*a*) 35 grams of potassium iodid are dissolved in 100 c.c. of distilled water. (*b*) 17 grams of mercuric chlorid are dissolved in 300 c.c. of hot distilled water. Solution *b* is added to solution *a* until a permanent precipitate forms. Dilute to 1000 c.c. with a 20 per cent. solution of sodium hydroxid. Again add solution *b* until a permanent precipitate forms. It is now allowed to stand until it becomes clear. Nessler's Reagent should be kept in a glass-stoppered bottle. It improves with age.

Alkaline Permanganate. Dissolve eight grams of potassium permanganate and 200 grams of potassium hydroxid in a liter of distilled water. Boil the solution until about one-fourth has been evaporated; then add ammonium-free distilled water to make up the liter. This solution must be tested for ammonia, the amount determined, and the necessary deduction made in each test.

The test requires a glass retort connected with a Liebig condenser. The retort and the condenser must be thoroughly washed out with ammonium-free water before inaugurating the test. 500 c.c. of the water to be analyzed are poured into the retort and alkalinized with 5 c.c. of the sodium carbonate solution. A piece of pumice stone is heated to redness and dropped into the retort. The water is gently boiled until 50 c.c. has been distilled. The distillate is poured into a cylinder of colorless glass with a diameter of 2.5 c.m. and a capacity of 100 c.c. Two c.c. of Nessler's Reagent added to the distillate in the comparison cylinder produce a yellowish-brown color, which is fully developed in about five minutes. The intensity of the color depends upon the amount of ammonia present. Into another comparison cylinder, the same as the one first used, are introduced 50 c.c. of ammonium-free water, a small but known quantity of the ammonium chlorid solution, and 2 c.c. of Nessler's Reagent. The object is to make a solution that will in color be as near as possible to the water tested. Several solutions with varying quantities of the ammonium chlorid solution may have to be made before the color is matched exactly.

As the same amounts of ammonia always produce the same color, then, knowing the quantity of ammonia in the control test, we can readily determine the amount of ammonia in the sample tested.

Continue the distillation and collect the distillate in lots of 50 c.c. until no reaction occurs upon the addition of Nessler's Reagent. For each 50 c.c. of distillate it is necesary to make control comparison tests, and then by adding the results thus obtained we determine the total nitrogen existing as free ammonia.

As ammonia is formed in the decomposition of urea and certain nitrogenous compounds, it is useless to prolong the distillation beyond the fourth or fifth distillate, as in such instances the evolution of ammonia may continue indefinitely.

After the evolution of ammonia ceases, to the residue in the retort are added 50 c.c. of the alkaline potassium permanganate and the process of distillation resumed, and the nitrogen in each 50 c.c. determined as before, remembering to make due allowance for the ammonia in the permanganate solution.

The ammonia obtained by the first process is the "free ammonia;" while the second process determines the "albuminoid ammonia." It is better not to add the alkaline potassium permanganate until the test for free ammonia is completed.

Nitrates. A known volume of water is evaporated to dryness in a platinum or porcelain dish. One c.c. of phenolsulphonic acid, made by incorporating 37 c.c. of strong sulphuric acid and 3 c.c. of distilled water with 6 grams of pure phenol, is added to the residue, and the two thoroughly mixed. Add one c.c. of distilled water, three drops of strong sulphuric acid, and gently warm the dish over a water bath. Dilute the solution with 25 c.c. of distilled water, add an excess of ammonium hydroxid, and again dilute with water sufficient to make up 100 c.c. By this procedure, the water is imbued with a yellow color through the formation of ammonium picrate—brought about by the conversion of phenolsulphonic acid into picric acid by the action of the nitrate and by the picric acid combining with ammonium hydroxid to form ammonium picrate. The intensity of color is proportional to the amount of nitrate present.

One c.c. of a potassium nitrate solution (0.722 gram of potassium nitrate, heated to fusing temperature, dissolved in 1000 c.c. of water; one c.c. is equivalent to .0001 gram of nitrogen) is evaporated in a dish and treated in the same manner as was the sample of water. The test solution and the water are compared and the color made to match. The necessary data for estimating the nitrate is supplied by the comparative volumes of the liquids, as for example; suppose that 15 c.c of water are used in the test, and this is diluted to 100 c.c.; further, that it is necessary to dilute the control test to 200 c.c. to obtain the desired color, the amount of nitrates is determined thus: 200 : 100 : : .0001 : x. x = .00005 N. in 15 c.c. of the water, therefore, in 1000 c.c. there are 0.0033 of N.

Nitrites. The determination of nitrites is executed by

Ilosvay's modification of Griess' test. The advantages of Ilosvay's method over the original test is that it develops the color more rapidly and the test solutions are more stable.

The following solutions will be required in the performance of this test:—

Para-amidobenzenesulphonic Acid. Dissolve 0.5 gram of para-amidobenzenesulphonic acid (Sulphanilic Acid) in 150 c. c. of dilute acetic acid having a sp. gr. of 1.040.

a-amido-naphthalene Acetate. One-tenth gram of naphthylamine is boiled in 20 c. c. of water and filtered through washed absorbent cotton; it is then mixed with 180 c.c. of dilute acetic acid. All water and utensils must be free from nitrites, for so sensitive is the reagent that appreciable quantities are absorbed from the air.

Standard Sodium Nitrite. Dissolve 0.275 gram of pure silver nitrite in pure distilled water, and add of a dilute solution of sodium chlorid until precipitation ceases. Add sufficient distilled water to make 250 c.c., and stand aside until clear. Keep the solution in the dark. For use dilute 10 c.c. of this solution with 90 c.c. of distilled water.

For each c.c. of the dilute solution employed in the test there is present .00001 gram of nitrogen.

The test is as follows: Pour 25 c.c. of water into a color comparison cylinder, and then with a pipette add 2 c.c. each of the sulphanilic acid and the amido-naphthalene acetate solutions. There should be a pipette for each solution.

Into another cylinder place 1 c.c. of the standard sodium nitrite solution, and then sufficient nitrite-free water added to make up 25 c.c. This is now treated as was the first.

After the expiration of five minutes the two are compared, and the one which is darker in color is diluted with pure distilled water until the color appears the same.

The calculation is made in the same way as that for nitrates.

Poisonous Metals. The most important mineral poisons found in water are *arsenic*, *lead*, *copper*, and *zinc*. The constant presence of any of these minerals is sufficient to condemn water for drinking purposes.

Arsenic is most conveniently detected by Reinsch's test. This test is executed by taking 1000 c.c. of water, rendering it alkaline with solid sodium carbonate free from arsenic, and then evaporating it in a porcelain dish almost to dryness. Three c.c. of water are introduced into a test tube and strongly acidulated with hydrochloric acid. A small piece of copper foil is dropped into the tube. The liquid in the tube is boiled, and if the copper remains untarnished the reagent is free from arsenic and the test is proceeded with. The residue from the water is rendered acid with hydrochloric acid, and added to the reagent in the tube, when it is again boiled for several minutes. If arsenic is present it will form a steel gray coating on the copper. The copper is withdrawn, placed in a perfectly clean and dry tube. The tube is gently heated near where the copper lies; the arsenic sublimes and collects at the cool end of the tube. The deposit examined with a microscope will, if it is arsenic, be seen to consist of octahedral crystals.

Lead is easily detected by pouring the water into a tall glass cylinder and adding a few drops of ammonium sulphid. If lead be present, lead sulphid is formed, which is manifest as a brownish-black precipitate. This precipitate is differentiated from that of iron in not dissolving upon acidulating with hydrochloric acid, and from that of copper in not dissolving upon the addition of potassium cyanid.

Copper is readily detected by pouring the water into a tall glass, acidifying it with acetic acid, adding water impregnated with hydrogen sulphid. The precipitate closely resembles that of lead, but may be differentiated by adding about one c.c. of a strong and pure solution of potassium cyanid, which dissolves the copper precipitate, while the lead precipitate remains unaffected.

Zinc can be detected, even to the slightest trace, by the test proposed by Allen. The water, rendered slightly ammoniacal, is heated to boiling and then filtered. Upon adding a few drops of potassium ferrocyanid to the clear filtrate, a white precipitate is formed.

Biological examination of water (for method see Technic):—Bacteriologic examination of water is vastly important and may afford evidence either *positive*, *corroborative*, or *negative*.

Positive Evidence. Should bacteriologic examination demonstrate the presence of pathogenic organisms, the water is to be unhesitatingly condemned. This may be the case in typhoid fever, cholera, and allied diseases, and will, probably, be equally conclusive in a larger number of cases as our knowledge of the microbic causes of disease progresses, and improved methods combined with more extensive observation, enable us to more readily demonstrate the presence of pathogenic forms. It seems not improbable that dysentery in its epidemic form may have a cause demonstrable by bacteriologic examination; while the demonstration of pathogenic organisms proves the danger of water, it may be considered as equally positive that water continuously free from all forms of bacteria, at least containing but few and these of the saprophytic variety, is probably a desirable water from a sanitary point, provided, of course, that in other ways it be unassailable.

Corroborative Evidence. The abundant presence of bacteria, more especially those constantly found in decomposing fluid, bacilli, cocci and spirilli, are considered indicative of dissolved organic matter, and prove the presence of suitable pabulum for the sustenance of that form of life, and hence the possible pullulation of pathogenic forms should they gain ingress. When the number of bacteria have suddenly and notably increased in a given water supply it should become immediately the object of suspicion. As an example of the importance of this assertion one has but to study Koch's article on "Water Filtration and Cholera;" more especially the reference to the cholera outbreak in Altona. (*Zeitschrift für Hygiene und Infectionskrankheiten*, July 7, 1893.) Attention is called to the rapid increase in the number of bacteria to 1500 per cubic centimeter immediately preceding the outbreak, thus indicating a faulty water supply, the fault afterward being proven to have originated in the filter-beds. This, of course, raises the question of the *number of bacteria* which may be present without endangering the consumer. No positive answer can be given, but experience with water supply must form the basis upon which opinions can be formulated. Thus, should a water supply under observation show a constant presence of bacteria, say to the number of fifty or one hundred to the cubic centimeter, without any apparent detriment to the consumer, a sudden increase of three or four times the normal amount must indicate a possible source of infection. If the number present in the water at its source be unaltered and there be a marked increase at the point of distribution, the storage or filtering accommodation must be the source of danger, and if the number at the point of distribution exceed that formed in the unfiltered water the filter must be sadly at fault. It is unnecessary to multiply examples, for any one watching the bacteriologic condition of a water supply must see from time to time the amount of corroborative evidence which his examination will afford.

Negative Evidence. It has been the preponderance of such evidence which has brought constant biological examination of water into disrepute ; closer observation will, however, show that the fault has not been so much in the theory involved as in its faulty application. A pint bottle of water all from one source no more represents a water supply, biologically, than an aquarium does the piscatorial product of a stream. It is frequent and repeated examinations of one and different samples from varying sources which offer the best opportunity for detecting impurities, as in this every unflushed main, blind-end pipe, etc., may be shown to be a source of danger.

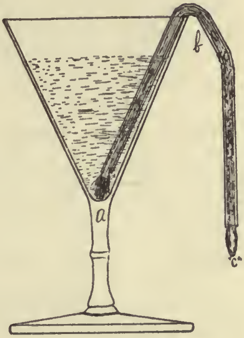
A constant number of bacteria, varying but little in kind, and purely saprophytic in action, may be considered as negative evidence, although, as already indicated, the true reading may be a high degree of purity, certainly not the reverse.

Microscopic Examination of Water. Often the detection of sewage contamination will depend entirely upon the elements shown to be present. The efficiency of the test is largely dependent upon the care manifested in its execution. Repeated examinations will be necessary in order to positively exclude sewage ; occasionally, however, a single carefully-made examination will detect its presence. Where at any point the stream is known to contain sewage, the examination should begin with water selected from that point, and the character of the mixture determined as a starting point. With this information to start from, but little difficulty may be encountered. The bed of the stream should be examined from place to place, in order to determine if possible whether there is continuous deposition of the contamination, and, if such be the case, it may be considered proven that any sudden increase of current will land the loosely packed material lower in the water-course, and eventually in the distributing system. The same care should be taken in examining the water itself, from point to point, at different times and under varying conditions of clearness. As a rule, the best results will be obtained when the water is clear and the current as rapid as can be obtained while the water is not muddy; if the water is very muddy the constant sedimentation which is going on keeps the sewage falling to the bottom, and does not give the proportionate increase that one would be likely to expect with the enormous quantity of suspended inorganic matter present. It will, however, be found that this rule varies often, and that the best results will depend upon frequent examination rather than selected times for study.

For the examination a good half-inch and quarter-inch or one-sixth-inch objectives will be needed, and preferably artificial light. The water to be examined is taken from a point where the bed is shallow, but the current not swift, if such a point can be obtained, and if possible the quantity taken is large; to prevent the carrying of a large bulk, where it can be so arranged, partial sedimentation is allowed to take place at the point of collection; this can be arranged for by taking a barrel with a tap about two inches above the bottom on one side, so arranged that the water can be drawn off, all but a small quantity, which contains the sediment. Twelve hours will be all the time which will be needed for the deposit of the sewage in the barrel. After the supernatant fluid is drawn off, the remaining water, which contains the sediment, is transferred to a large bottle or jug and removed to the laboratory. Here it is placed in a conical glass, such as is shown in the accompanying illustration, and further sedimentation allowed to take place. In very warm weather, or if the amount of sediment be small, it may be necessary to hasten the process or to make it more thorough, in which case the candlewick filter used in urinary analysis will be found useful; this is constructed as follows: A tall conical glass, or graduate, is filled with the water to be examined; a large **U**-tube of glass is then filled with a strand of candlewick, drawn through the entire length of the **U**-tube, and of such size as to fit quite snugly; the **U**-tube, or an ordinary glass tube bent for the purpose may be used, is then inverted and allowed to hang over the side of the vessel, as shown in the cut. By capillary action and siphonage the fluid is emptied from the glass, and all the suspended matter collected on the lower end of the candlewick, the end which was in the glass. The sediment is now placed upon microscope slides and examined in the usual manner.

There are some organic elements which are readily detected, and these must be sought for with great care. Striped and unstriped muscle fiber, especially the former, may be considered as positive evidence of contamination. Occasionally small aggregations of cartilage cells will be found, or remnants of yellow elastic tissue, and, though less commonly, such animal parasites as usually accompany sewage.

FIG. 61.



CANDLEWICK FILTER.

a, Conical glass, containing water. *b*, Curved glass tube, containing candlewick. *c*, Point where the water flows out to extra vessel, not shown. The sediment will be collected on wick over point *a*.

To Determine the Source of Water. This is often a most important factor and frequently attended with great difficulty. Wells, cisterns, cesspools, cellars, etc., are often found to contain water which is evidently an addition or from a new source, and it may be important, as in cellars or in wells where the addition has been proven to be a contamination, to find whence it comes. If the source be suspected and accessible some chemical may be added, and, if the suspicion be correct, the added element may be detected in the water under examination.

Leffmann and Beam advise the use of lithium or strontium chlorid, both easily detected by ordinary methods. Fluorescein has been used, and, indeed, any of the so-called anilin dyes, derivatives of coal tar, may be found useful. Fluorescein possesses a highly distinctive value in that a very small quantity will yield color to an enormous body of water.

Where the source be not suspected the problem becomes most difficult. A knowledge of the subsoil water in the surrounding earth is important, and if the product under investigation differs materially from the normal subsoil water it becomes evident that some other source must be sought.

Leffmann and Beam quote the following figures as parts of results obtained by them in association with Mr. Chas. F. Kennedy, Chief Inspector to the Board of Health, Philadelphia :—

		Cellar Water.		
	City Supply.	*No. 1.*	*No. 2.*	*No. 3.*
Total solids, ...	115	140	661	60
Odor on heating, . .	faint	faint	strong	urinous
Chlorin, ...	4	6.4	77.0	128.0
N. as nitrates, ...	0.7	1.0	3 5	none
N. as nitrites, ...	none	present	present	none

Subsequent investigation showed that sample No. 1 came from a leaky hydrant and had traversed twenty-two feet of subsoil. Sample No. 2 came from a leaky drain, as was presumed from the high degree of impurity. "In the third sample the high chlorin, strong urinous odor, and absence of nitrates and nitrites pointed unmistakably to recent and profuse contamination with sewer water."

CHAPTER VI.

AIR.

In a sense air may be considered one of the foods, as everything which enters into the nutrition and assists in the building up of new tissues or the repair of old, and the production of heat and force, either directly or indirectly, is to be considered as a food. Air is composed, approximately, of seventy-nine and a fractional part of nitrogen and twenty parts of oxygen, by volume, a trace of carbon dioxid some ammonia, and aqueous vapor. In large manufacturing districts other gases will be found frequently present in the air. The wonderful faculty which the air possesses for purifying itself by currents and exposure to oxidizing influences is such as to render it always pure, provided the purifying process is not resisted by mechanical means, usually the outgrowth of man's ingenuity. In the absence of this purifying process the earth would be surrounded by a stratum sufficiently thick and containing impurities in such enormous quantities as to be fatal to all forms of animal life.

Impurities in Air and their Source.

The contamination of air due to respiration is vastly important. Formerly the percentage of carbon dioxid was considered the test for impurity due to respiration, but more recent experiments seem to prove that organic matter, either as gas or minute suspended particles, is vastly more important. Each adult gives off on an average about .62 cubic foot of carbon dioxid per hour; the adult male exceeds this amount, while the female, children, and the aged produce less. The presence of this product of respiration in the air is so modified by natural ventilation that accurate observations cannot be adduced. It would seem that in habitations the excess is reached during the sleeping hours, therefore mostly at night, while in the industrial occupations, factories, etc., the maximum is reached during the hours of highest humidity, as the aqueous vapor retains the organic matter; when continuous labor is going on both day and night, ventilation equalizes or reduces the excess of the day. Hospitals, barracks, prisons, and stables contain the largest percentage of carbon dioxid. Thus de Chaumont states that, with outside air containing less than .5 parts in 1000, a barrack would probably show over 1.5 parts, a hospital about one part, and a prison two to three parts per 1000 volumes. The one benevolent feature of carbon dioxid is its rapid diffusibility, in this respect being vastly more active than the aqueous vapor and organic matter exhaled from the body.

Organic Matter. Exactly what this organic matter is which is given off by the body is not known. A certain quantity we may recognize as parts of the histologic structures of the body, such as hair, epithelial cells, and granular detritus the products of organic life. These have not, however, any significance as air contaminants; it is the products exhaled, probably as gases, or certainly partly in a vaporous condition, from the skin and mucous membranes. These products do not include the aqueous vapors given off by the skin and lungs, the aggregate of which varies between thirty and forty ounces during the twenty-four hours. The presence of organic matter is readily demonstrated, although its character is unknown. Thus, if the products of respiration, as contained in the expired air, be passed through permanganate of potassium solution they decolorize it; if passed through sulphuric acid, they darken it; if condensed in chilled receivers along with a certain amount of aqueous vapor, an offensive product results which is nitrogenous and oxidizable; if dissolved in water, a fetid odor is given off. If hygroscopic structures, such as clothing and absorbent walls, paper, floors, etc., be brought in contact with the exhaled product, it imparts a recognizable odor to them. The race odor, characteristic of the negro, for example, is probably nothing more than an organic impurity which we detect more readily than the product of our own vitality.

Not knowing its composition except that it is nitrogenous and oxidizable, we have no test available for its quantitative estimation. It usually, although by no means invariably, exists as a proportionate impurity with the carbon dioxid. Thus when the latter reaches .8 parts in the 1000, the organic matter becomes recognizable by the sense of smell, and when the carbon dioxid reaches 1 part per 1000, the odor becomes quite marked. While this may be true, it is not always so by any manner of means. Thus the writers have observed, in the "slums," rooms with wide open windows offensively laden with what, to the senses, seemed to be organic products of respiration, while the air contained but little more carbon dioxid than the outside atmosphere. This has been presumed to arise from faulty or partial diffusion of the organic matter, while the CO_2 diffuses rapidly. The fact that in a single closed apartment certain areas would be apparently more heavily laden than others, quite independent of heat or air currents, has been explained as depending upon the presence of organic matter in clouds, thus assuming that it exists in the atmosphere in a condition analogous to that of water. Another consideration not often presented is the possibility of organic matter increasing in intensity after the removal of all occupants from the room. This is largely attributed to the presence of bacteria. Thus it has been found that the presence of organic matter is in direct proportion to the number of bacteria present in the atmosphere; furthermore, where the bacteria belong to the bacillus, coccus or spirillum group the contamination is probably more recent, while the mold fungi come as the above disappear from the air and colonize by sedimentation on surrounding objects. Reinhabitation of rooms again diffuses the bacteria proper and ventilation removes the molds; this is probably brought about by the rise in temperature which takes place when the room is again occupied, the molds not growing in such luxuriance under conditions favorable to the growth of bacteria proper. While an apparent relation seems to subsist between the organic matter and the biologic condition of the air, no apparent connection can be demonstrated between the amount of carbon dioxid and bacteria. It would therefore appear that examination of the air for bacteria might approximate the contamination by organic matter, or *vice versâ.*

But little is known of the significance of organic matter or bacteria in the air, provided, of course, that the latter are not members of the pathogenic group. As the organic matter is undergoing oxidation, it must of necessity be depriving the air of oxygen and thus lessening the standard of purity, aside from the injurious action which it exerts *per se.* In considerable quantities it must not only lessen the available oxygen, but manifest itself as an actual poison. As it has been demonstrated that anything which lessens the standard of normal tends to increase the ability with which bacteria secure lodgment in the economy, and as bacteria form a constant associate contaminant with the organic matter, one can but regard the combination as one imminently prejudicial to health. No one hesitates to pronounce suspended or dissolved organic matter in water a condemnable contamination, and there seems to be no valid reason for making an exception in the case of air. The symptoms produced by the noxious agent are headache, dulness of perception, a sense of drowsiness, and a general feeling of *malaisé.* These are symptoms experimentally produced, as no observations in actual practice have been made by reason of the fact that excess of carbon dioxid is usually present, and the symptoms of the two are combined. It would seem that where one is long exposed to the influence of carbon dioxid alone, the symptoms, if it be sufficiently concentrated to induce symptoms, rapidly disappear when the cause is removed; with organic matter, however, the depression, headache, and muscular weakness induced endure for several days, and are not infrequently followed by diarrhea and gastro-enteric manifestations attributable to the swallowing of suspended matter lodged in the throat and mouth or to the swallowing of oral mucus which has absorbed the noxious agent during respiration.

Products of Combustion. Modern heating, even in its cruder forms, precludes contamination of the atmosphere from ordinary fires. In the industries, however, carbon and its combinations with oxygen and sulphur, sulphur and its combinations with oxygen, oxygen and hydrogen, arsenic, copper, lead, and occasionally zinc, find entrance to the atmosphere either in gaseous combinations or as minutely divided particles. Vitiation from light production is the most common contaminant which results from combustion in habitations and often in manufactories, more especially those one might designate as the "sedentary occupations," such as shirt-making for women, jewelers' engraving, or clerical occupations for men. In these, often conducted in badly ventilated and poorly lighted apartments, vitiation by artificial lighting is often a matter of great importance. In this country we have to deal only with gas, oil, and electricity as lighting agents. The latter, of course, by the incandescent system, adds nothing to the surrounding air; by arc light, however, it is claimed that ozone is produced, which, as the nascent form of oxygen, offers no objections, indeed, may be considered a desirable feature. Oil as an illuminant is now in very general use, and if consumed in properly constructed lamps yields carbon, carbon dioxid, and water; the quantity of carbon is inestimably small in well-cleaned lamps, and excess in production is due to faulty draft or dirty wick. For every pound of oil consumed an equal amount of aqueous vapor is produced and about thirty cubic feet of carbon dioxid, while for the combustion over one-hundred and fifty cubic feet of air will be consumed. Coal gas from a fish-tail burner will produce for every cubic foot consumed two cubic feet of carbon dioxid and a trace of pure carbon; if a Bunsen burner be used the consumption of the carbon will be complete, but the quantity of carbon dioxid will proportionately be increased. The Argand and Welsbach burners consume more gas, the former giving off more pure carbon and the latter more carbon dioxid than the fish-tail burner.

Contamination by Trades; organic matter from other sources. Aside from the contamination already referred to as due to processes of combustion, other contaminations arise from slaughter houses, markets, etc. These include so-called odor nuisances, in which no positively injurious element can be demonstrated, as *e. g.*, glue factories; whatever else may be true of these, no one not accustomed to them can tolerate their disagreeable odor. In conversation with an expert employed by the manufacturers of fertilizers near the city of Philadelphia, he expressed the opinion that their workers were as free from disease as laborers engaged in any other industrial pursuit. While this may be true, it is to be remembered that the employees are working from choice, *i. e.*, the men are only those who can tolerate the prevailing condition and find no physical defects follow. This is a matter of vital importance, and statisticians rarely consider it. Nursing cannot be considered as a healthful employment, and yet from a rather extensive experience it does not seem that nurses suffer as the result of their chosen occupation. Why? It seems probable that the selective affinity, which led to the choice formed a part of the resistance which permitted a continuance of the labor. Conclusions are often drawn from too superficial observations. In the sanitary supervision of a large sugar manufactory no complaints of ill health due to the odors or atmosphere which pervades the building has come to the writers' notice, but many men who have been stevedores and, therefore, accustomed to the most laborious exertion, have declined proffered work in the refinery, stating that they could not eat when subjected to the odors incident to the manufacture of sugar. In other words, a generous percentage of laboring men could not, unless accustomed by an induced tolerance, enjoy health in the presence of noxious odors. Besides, as these odors largely arise from the presence in the atmosphere of organic matter in varying stages of decomposition, they must of necessity be injurious to public health. What is true of these must be doubly true of sewerage emanations. And no amount of argument or misinterpreted facts can remove the observation, almost daily brought to our notice, of lost appetite, headache, nausea, and even vomiting, the sole origin of which was the temporary sewage-laden air incident to the cleansing of a noxious cesspool. These odors are largely products of the microörganisms of decomposition, products held either in solution or suspension in air, and are again comparable to similar if not the same elements retained in suspension or solution in water. They cannot be baneful in one and innocent in the other instance.

The *air of marshes*, while usually considered as possessing specific impurities, hardly differs from other decomposing organic matter (vegetable) where there is presence of heat and moisture. The excess of moisture probably deters dissemination of the poison until saturation occurs, and then the products of decomposition are poured forth in enormous quantities. Another potent agent in complicating the process is the change of temperature incident to the revolving cycle of the twenty-four hours. Thus, with the advent of night the reduction of temperature leads to several changes, *e.g.*, (1) cooling of the water enables it to retain gaseous elements, which would be given off at higher temperatures; (2) a heavy protecting blanket of aqueous vapor checks radiation and faciliates the growth of parasitic life in the marsh-water and also precludes the dissemination of gases by lessening if not temporarily abolishing all currents toward higher land. With the advent of heat, in the morning hours, poisons engendered during the night are poured forth; the aqueous vapor or temporary cloud becomes again a part of moving air currents and floats off with the poisons, which have become a part of it during the night; the marsh, again heated, gives off the gaseous organic products which have been developed during the cooler hours, just as ammonia water loses its ammonia by warming. Let us see the importance of this; what inferences can be drawn? In a malarial area, if the above be correct, the early morning and late evening hours must be more dangerous, and the midday and afternoon less noxious hours—the evening hours fraught with danger in the marsh or lowland, the morning most unsafe in the path of the evolving currents, while during the middle hours of the day dissemination is rapidly progressing and the moving currents give air containing a minimum of organic matter. Facts bear out the theory. In malarial districts early-to-bed and late-to-rise individuals suffer least from their environment, the reverse being equally true. A Mississippi river pilot informed the writer that no crew could continuously stand night and morning runs through malarial areas, and the owner of a large plantation near Memphis stated that whites who went to bed early and slept late escaped malarial influence for an indefinite period. His facts were correct, but his belief that the sleep was the determining factor in the temporary immunity was incorrect.

Emanations from made ground, which contains organic matter in the shape of decomposing cast-off clothing, old shoes, waste and street dirt, differ from other organic air contaminants only in degree and the amount of moisture present, and deserve the same consideration, *pro rata*, with pollutions from marshes and noxious industries. The same is true of products arising each autumn from the decaying vegetation incident to the season.

Carbon Dioxid or CO_2 is constantly present in the air, although in an extremely small amount, in the open air, from .1, possibly to .3 or even .5, and in closed rooms, badly ventilated, it not infrequently exceeds one per one thousand volumes. At one time great importance was attached to its presence, and air contamination was considered as directly proportionate to the amount found. It was presumed to have been the active agent in the "Black-hole of Calcutta," where out of 146 prisoners placed in at night, 23 were alive in the morning, but "putrid fever" (?) carried off some of the survivors; and in the death of nearly fifty per cent. of the passengers on a steamer where the hatches were battened down for a single night. In the first place, these commonly cited examples prove nothing, as no observation of the air condition is available, and in the second place they have no more bearing on sanitary science than examples of "leaden hail" on a battle field demonstrate the noxious effects of the metal upon public health; it is not probable that the CO_2 was, in either case, the active agent.

The given percentage of carbon dioxid which is perceptible must vary enormously; besides, if an individual be in an atmosphere which is slowly becoming vitiated by the gradual introduction of carbon dioxid, he is not conscious of the change, the system either adapting itself to the poison circulating in the air, or the development of symptoms is so slow that the individual is scarcely aware of the change, or, and this is most likely, the symptoms produced are anesthetic, and made up from more factors than the dioxid alone.

Pettenkofer and Voit observed no discomfort in an atmosphere containing ten parts of carbon dioxid to the thousand volumes; Dr. Smith observed diminished circulatory activity and acceleration of the respiration movements in the presence of much greater amounts. It seems not improbable that, in the absence of organic matter, carbon dioxid rarely, if ever, under ordinary circumstances, becomes a dangerous air contaminant. It may, and probably does, act by displacing the oxygen, and robs the air in this manner as much as it contaminates. It is not probable that carbon dioxid becomes dangerous until it reaches a very concentrated form, probably from twenty to twenty-five or even fifty per cent. However, air containing above 1.5 volume per thousand is to be considered sufficiently impure to be rejected by the sanitarian, as the action may be cumulative in character, and, as an excreted product of vital processes, its retention might lessen vital resistance, and in this manner act as a predisposing cause of disease.

Carbon monoxid, or CO, is highly poisonous and its poisonous character is rendered more dangerous by its possessing no odor. The percentage present in the atmosphere, in order to give rise to symptoms, may be very small. We have reason to believe that when it reaches from five to ten or twenty parts per thousand it will prove rapidly fatal to human life. Very small percentages kill mice and rabbits and other lower animals. The gas is largely intermixed with other gases and used for illuminating purposes; in this country it is used mixed with sufficient coal gas (carbon monoxid is known as water gas) to give the mixture a distinct odor before it is delivered for lighting purposes. It has been proposed to give it an odor by the use of pyridin or other volatile odorous materials. Coal gas may, of course, be present in the air in sufficient quantities to prove injurious to health, or if its presence be protracted, or if it be concentrated, may cause death, exactly as the carbon monoxid of which it is largely composed.

Other Gases. Among the other gases which may be present in the air and give rise to difficulty are *hydrogen sulphid*, *carburetted hydrogen*, *carbon bisulphid*, and mixtures composed of these and others less frequent. These largely arise in industrial pursuits and have very little practical bearing. They are, of course, noxious in proportion to quantity present, and probably assist other impurities in the induction of diseases. In mines we have the consideration of gases due to the oxidation, either slowly or by explosion, of the carbon present; also the presence of carburetted hydrogen and other gases. Their source does not alter the character of their action, and they are there only more noxious than elsewhere by reason of the deficient ventilation which usually predominates.

Diseases Attributable to Atmospheric Impurities. Formerly air was believed to be the most prolific agent in the production of disease. This, no doubt, arose from deficient knowledge of disease etiology, and as little was known of the air, the sum of the two noughts was believed to be enormous. As we progressed in our knowledge of diseases and their causes, as humoral pathology disappeared, by exclusion, many of the diseases attributed to the air were proven to have arisen from other causes, so that to-day the air is looked upon almost exclusively as a carrier only.

Parasitic Diseases. The diseases which are most prominent and give rise to most trouble, in connection with the air as a carrier, are all those diseases due to animal or vegetable parasites, and which we have been pleased to speak of as contagious or infectious diseases. Thus, tuberculosis, smallpox, scarlet fever, and similar diseases can undoubtedly be communicated through the atmosphere. Not only is this true of the highly contagious diseases, but it has been proven that skin diseases may be communicated through the atmosphere. The vegetable parasites found in the various forms of tinea, including the tricophyton tonsurans, have been obtained from the atmosphere in the ward of a skin hospital several weeks after the last patient had been discharged, thus establishing the possible spread of these diseases through an infected atmosphere. The constant presence of the microörganisms of suppuration in the air demands, to a large extent, the use of antiseptic surgery instead of aseptic operative procedures. In the presence of the specific organism of consumption the fibroid and catarrhal pulmonary conditions become tubercular. Whether he cause of malaria be an animal or vegetable parasite or at poison, the spread of the malady through the air as a carrier is now universally admitted.

Artisans' Phthisis. Prominent among diseases due to impurities in the air we have the various forms of fibroid or interstitial pneumonia, or artisans' phthisis; that is a chronic inflammatory process going on within the lungs and due to the inhalation of air containing some suspended matter which is deposited in the lung tissue itself. As examples of this we have the phthisis of the glass grinder, the needle and scissors grinder, the brick maker, stone cutter, a form of the disease occurring in laborers in shoddy and tobacco manufactories; in the latter instance the suspended matter acts as a poison as well as an irritant.

Chemical Toxemia. There are certain inflammatory processes due to the handling or manufacture of chemicals, such as bichromate of potash, necrosis due to mercury and phosphorus, and the chronic forms of poisoning due to lead, as seen in the painter, the manufacturer of lead products, and in the plumber. Another very good source of metallic poisoning is arsenic gaining ingress to the air of rooms from wall paper which has been colored by some of the arsenical pigments, and occasionally from freshly painted walls, the paint pigment containing arsenic. For the most part, it may be said that any solid material floating in the air and subsequently gaining ingress to the lung will infiltrate and set up a chronic inflammatory process in the lung itself, or, as is the case with arsenic, induce systemic symptoms identical with those brought about by the administration of the drug in the usual manner, the intensity being dependent upon the amount of the poison inhaled. Further, it is to be noted, that suspended matters in the air will reach the stomach, by the swallowing of oral, nasal, or upper pharyngeal mucus upon which the material has adhered.

Accessory or Predisposing Elements. It seems most probable that many air contaminants are predisposing elements in the spread of disease, although not themselves disease-producing. Thus the artisan's phthisis becomes tuberculosis, large percentages of organic matter favor the spread of typhus fever, diphtheria, diarrhea, and, possibly, dysentery and cholera ; ulcerated sore throat, tonsillitis, puerperal fever, pyemia, septicemia, and that now historical disease, hospital gangrene—in other words, the so-called " dirt diseases" are most frequently associated with air impurities. The young and physically weak shop girls, clerks, and others under similar conditions, may find air impurities the determining factor in turning the scale of health. Deficient supply of oxygen constitutes a form of starvation in which it is probable that the manifestations are cumulative in character and for any given time so obscure that no positive conclusions can be drawn. As respiration is not a purely voluntary process, as is eating, the close watching of factories, workshops, and the day home of the laboring classes, who are so indifferent, is demanded in the interest of public health, as much as the sanitary inspection of their clothing and food.

Air Examination.

Collection of Samples. The method of collecting a sample of air involves as much care, attention, and judgment as the method for collecting a sample of water. The vessel selected should be a wide-mouthed, glass-stoppered bottle, having a capacity of about two gallons. The bottle is kept clean and is made ready for use by rinsing several times with ordinary clean water and finally with distilled water. In collecting the sample, fill the bottle with distilled water which has been boiled. The bottle is held about four feet (the mean level at which air is inspired) from the ground and the water poured out; as the water flows away, the air rushes in and occupies its place. Mr. Angus Smith employs a flexible bellows, provided with a nozzle which reaches nearly to the bottom of the bottle. As the air in the bottle is pumped out a sample of the air desired refills the bottle.

Other methods are utilized, but these are the most simple and most efficient.

The air should be collected at the time, in the twenty-four hours, of its maximum impurity. The vessel in which the air is collected should have a label upon which is stated the date, current temperature and pressure, locality, and any other data which it may be desired to record. If it is necessary to transport the specimen any distance, the bottle should be sealed.

Analysis of Air.

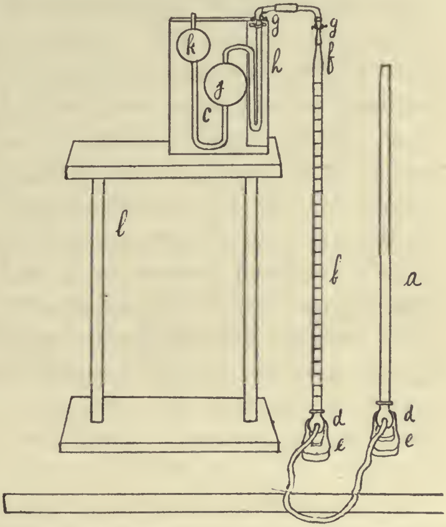
Estimation of Oxygen in the Atmosphere. The amount of oxygen present in the atmosphere may be most accurately and conveniently determined by the process known as *eudiometry.*

The apparatus required for the performance of this process are: 1. A gas-measuring apparatus, of which Hemple's gas burette may be selected as the most simple and the easiest manipulated instrument.

Hemple's gas burette consists of: (*a*) A plain glass tube of a uniform caliber throughout, except at the upper end where it is slightly enlarged. At the lower end is a short arm to which rubber tubing may be attached so as to connect it with tube *b*. The tube is fitted to a round, flat, iron base. (*b*) Another tube, contracted above that it may fit within a piece of rubber tubing, and thus connection established with the apparatus containing the gas-absorbing chemicals. This tube is graduated in cubic centimeters, has an arm similar to that of the preceding tube, and is, in a like manner, fitted to an iron base.

Absorption Pipette. The apparatus for containing the chemicals consists of a fine glass tube on which is blown two bulbs, and the tube bent as shown in the accompanying illustration. The upper bulb has, at least, a capacity of 100 c.c., and the lower one a capacity of 150 c.c. This apparatus should be mounted upon a wooden stand, with a piece of enamel forming a background to the U-tube. The reagent employed for oxygen is a solution of pyrogallic acid (15 grams) and caustic potash (50 grams) in distilled water.

FIG. 62.



APPARATUS FOR ESTIMATING THE AMOUNT OF OXYGEN IN THE AIR BY EUDIOMETRY.

Performance of Test. First collect and measure the air to be analyzed; place tubes *a* and *b* upon the same level, pour water into tube *a* until it and *b* are half full. Raise tube *a* until tube *b* is completely filled; then lower tube *a* and as the water refills tube *a* the atmospheric air fills tube *b*, when a pinch-cock is applied to the rubber tubing at the upper end of tube *b*, thus imprisoning the air.

Secure the two tubes on wooden blocks at heights necessary to insure the same water level in each tube, and thus get the same pressure within the tube as obtained in the room. Now read off in c.c. the volume of air in tube *b*.

By means of a short piece of rubber tubing connection is established between tube *b* and the "absorption pipette." The piece of rubber tubing should be as short as possible. Sufficient of the pyrogallic acid solution to fill the lower bulb is poured into the apparatus, and the height to which the solution rises marked off on the enamel background. By removing the clamps communication between tube *b* and the "absorption pipette" is established.

To bring the air in tube *b* in contact with the reagent in the "absorption pipette" elevate tube *a;* the water flowing into tube *b* forces the air into the absorption pipette. This is repeated several times, that the solution may absorb all of the oxygen.

Finally the air is drawn into tube *b*, great care being observed to see that the level of the pyrogallic acid solution corresponds to the mark upon the enamel background. The level of the water in the two tubes is brought to the same point as it was in the beginning of the process, and the volume again read off in c.c. The difference between the first and second readings indicates the quantity of oxygen present in the sample.

To conclude the test, again expose the gas in tube *b* to the acid solution; when if the volume remains unchanged all the oxygen is absorbed and we have a "constant reading;" otherwise the process must be continued until the readings become constant.

It is absolutely essential to the successful consummation of the test that no outside influences, which are likely to affect the temperature of the tubes or of the "absorption pipette," be introduced; therefore, the necessity of handling the tubes by their iron bases only.

Ammonia in small traces (0.06 milligrams per cubic meter) is always present in the atmosphere, in combination with an acid forming usually the carbonate or chlorid, though occasionally it is found as the nitrate or sulphate. Ammonia can easily be detected by moistening strips of filter paper with Nessler's reagent and exposing the strips in the air. Another test is executed by aspirating known quantities of air through pure distilled water and then testing for the ammonia as detailed under the chapter on water.

Carbon Monoxid (CO), when subjected to Vogel's test, can be detected even though it exists in only 0.03 per cent. Into the jar containing the air, pour a small quantity of pure distilled water; prick the finger and allow a few drops of blood to fall into the water. Shake the bottle vigorously and stand it aside for several minutes. Remove a small quantity of the fluid and examine it with a spectroscope; if carbon monoxid be present, the lines will be those of reduced hemoglobin. To confirm the test add a few drops of ammonium sulphid solution, shake the bottle, and then stand it aside for a few minutes. If, upon spectroscopic examination, any change has taken place in the lines, no carbonic oxid was present.

Another test, based upon the affinity of carbon monoxid for the subchlorid of copper, may be performed by first exposing copper turnings and copper oxid to strong hydrochloric acid, thus making a solution of the subchlorid of copper, and then treating a definite volume of air with this solution. The loss in volume of air indicates the amount of carbon monoxid. When carbon monoxid is present in less than one per cent. this test has no value, and we must depend upon Vogel's test to determine its presence.

Carbon Dioxid. For the determination of the amount of CO_2 in the air, Pettenkofer's method, though somewhat complicated, is one of the most accurate. To test the air by this method, we fill a dry, clean jar having a capacity of four or five liters, with the air which is to be examined, then pour in 100 c.c. of lime water, stopper the bottle with a rubber cap, and agitate thoroughly for several minutes. Pour the lime water into a four-ounce stoppered bottle and allow to stand. Draw off with a pipette two or three portions of 25 c.c. each and place in a separate 100 c.c flask. A few drops of pheno-phthalein solution added to the contents of the several flasks imparts a beautiful pink color. Then add drop by drop oxalic acid solution, 1.41 grams to the liter of distilled water, until the pink color disappears. Note the number of c.c. necessary to produce this effect in each of the several flasks and obtain the mean.

Determine the number of c.c. of the oxalic acid solution necessary to neutralize 25 c.c. of lime water. The difference between this and the mean number of c.c. required to neutralize the test solutions indicates the amount of CO_2 which united with the lime-water to form a carbonate.

A simpler test* may be performed by obtaining six flasks having capacity respectively of 150, 200, 250, 300, 350, and 450 c.c. and each stoppered with a rubber cap; 15 c.c. of fresh lime

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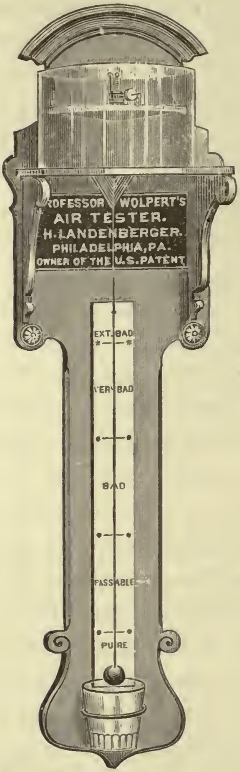
* This is the minimetric method of Mr. Angus Smith.

or baryta water is to be placed in each flask. The flasks are agitated for several minutes and the smaller one showing a precipitate noted. If it be the one of—

150 c.c.	capacity,	it indicates	.16 %	1.6	per	1000
200 c.c.	"	"	.12 %	1.2	"	1000
250 c.c.	"	"	.10 %	1.0	"	1000
300 c.c.	"	"	.08 %	0.8	"	1000
350 c.c.	"	"	.07 %	0.7	"	1000
450 c.c.	"	"	.05 %	0.5	"	1000

Fig. 63.



One Form of Prof. Wolpert's Air Tester; intended for the constant record of CO_2 in the air. The apparatus consists of a frame upon which is supported at the upper part, upon a shelf, a cylindrical glass jar with straight sides; in this jar is a "swimmer" of metal which accurately fits the sides of the jar with sufficient looseness to permit of easy rise and fall of the liquid upon which it is to rest. From this floater a siphon tube passes backward over the side of the jar, through the shelf, and discharges the contents of the cistern upon the cord, which is kept taut by the plumb attached to its lower end. The discharge is regulated by a micrometer screw. Immediately beneath the plumb is a glass receiver, into which falls any excess of the fluid descending upon the cord. A large percentage of the fluid evaporates from the cord and does not reach the glass below. Immediately behind the cord, but not touching it, is an enamel scale, upon which is lettered the percentage mark described in the text.

Prof. Wolpert's Air Tester consists (1) of a glass test tube 12 centimeters in length and 20 millimeters in diameter; on the side and near the bottom of the tube is a horizontal line indicating the height to which three c.c. of lime water will rise; the bottom is whitened with a black mark stamped upon it. (2) A glass tube with the lower end constricted and which when in operation is immersed in the lime water until all the air in the bulb, which is fitted to the upper end of the tube and has a capacity of 28 c.c., is forced through. The tube is then carefully withdrawn and the bulb again allowed to fill, when the process is repeated until the black mark upon the bottom of the tube, when looked at from above, is obscured. Note the number of times the air was discharged through the lime water, and by referring to Prof. Wolpert's table, which is supplied with the instrument, the amount of CO_2 in 10,000 parts of air may be obtained.

Another form of air tester, also known as Prof. Wolpert's, is shown in Fig. 63. The principle upon which it is based is the decolorizing effect of carbonic acid upon the red solution of sodium phenolphtalid.

By referring to the scale opposite the point at which the solution is decolorized we readily see the condition of the air.

Pure, indicates that the presence of carbon dioxid in the air is from 0.5 to 0.7 per mile.; passable, from 0.7 to 1.0 per mile.; bad, from 1.0 to 2.0 per mile.; very bad, from 2.0 to 4.0 per mile.; extremely bad, more than 4.0 per mile.

Directions for Use. Hang the instrument against the wall out of the influence of sunlight and heating appliances; fill the upper glass receptacle half full of the reagent and let it stand for an hour in a warm room with pure air (not in the sun) to remove some air bubbles, which may have been formed by pouring the liquid into the vessel; slip the tube of the rubber bulb over the capillary end of the siphon attached to the end of the swimmer and insert the swimmer. While the balloon is compressed into the liquid remove the pressure from the rubber bulb and the siphon will fill with the red liquid. Then pour a measuring glass full of the oil upon the red liquid around the swimmer to prevent evaporation and absorption of carbon dioxid; place the glass vessel upon the frame in such manner that the liquid drops over the channel on to the cord. At a temperature of 68° the drops should fall at the rate of a drop every two minutes; should the flow be slower or quicker, it can be adjusted by turning the micrometer screw in the desired direction. At first some of the drops may spring off the dry cord; to prevent this it is advisable to wet the same with pure water, by means of a camel's hair brush, all the way down. The cord can be used for a long time; should it become yellowish it can be cleared by washing it in water, then in alcohol, and again in water; its trifling cost, however, renders it preferable to replace it by a new one from time to time.

When refilling the reagent jar, place the funnel between the swimmer and wall of glass jar, on the bottom of the jar, and pour the liquid into the funnel.

It is advisable to clean glass and metal parts of the instrument from time to time, but only tissue paper should be used for that purpose.

The formula for the reagent is as follows:—

No. 1. Phenolphtalein Solution. Dissolve one gram (15 grains) of phenolphtalein in ½ liter (about one pint) 95 per cent. alcohol.

No. 2. Soda Solution. Dissolve 5 grams (75 grains) of crystallized carbonate of soda in ½ liter (about one pint) distilled water. Unless the chemically pure crystallized carbonate of soda is on hand, care should be taken when using regular washing soda that the white, mealy substance be first removed, and only the transparent crystals made use of.

These solutions should be kept in well-closed bottles in a dark place.

To make one filling, which will last for about ten days, take of the—

Phenolphtalein solution, No 1,	30 c.c , or about 1 ounce.
Soda solution, No. 2,	30 c.c., or about 1 ounce.
Distilled water,	250 c.c., or about 8 ounces.

Sulphuretted hydrogen is detected even when existing in small quantities by exposing filter paper saturated with a solution of lead acetate to the air, when, if this gas be present, lead sulphid is formed, which turns the paper black. If this test is not satisfactory, the air may be aspirated through pure distilled water and the water treated with a solution of lead acetate, when a dark or black precipitate of lead sulphid is produced.

Ozone is best determined, both quantitatively and qualitatively, by Houzeau's test, which is as follows: Faintly reddened litmus paper is saturated with a solution of potassium iodid and then dried. The strips are exposed to the air, care being taken to exclude dust, direct sunlight, rain, and strong winds, when, by reason of the presence of ozone, the iodin is volatilized, thus setting free the alkali potash, which turns the paper blue. A standard scale of tints can be obtained with which to compare the test strips; the colors are matched and the quantity determined. The standard tints are prepared by exposing strips, prepared as above described, to known quantities of ozone.

Carburetted Hydrogen. Fire damp or marsh gas is the common non-illuminative diluent of coal gas and is present in the proportion of from thirty to forty per cent.

Carburetted hydrogen is present in large quantities in poorly ventilated mines, and often it accumulates and endangers life and property. The most convenient method for detecting carburetted hydrogen when present in large quantities in mines is by means of a Davy safety lamp. The gas passes through and burns within the cage, but the flame is not communicated to the outside, as the wire cage cools the gas to a temperature below the combustion point.

Carbon Bisulphid. When present in the atmosphere, carbon bisulphid produces serious nervous derangements. Its presence may be detected by a garlicky odor characteristic of the contaminant. It is highly inflammable, and when condensed to liquid form burns with a yellow flame, gives off fumes of sulphur, and leaves behind a yellow deposit.

Aqueous Vapor. The aqueous vapor present in the atmosphere may be estimated by hygrometers, and the best form to employ is the wet and dry bulb thermometers, for description of which see chapter on Climate.

The readings obtained from these thermometers, when applied to Glaisher's Tables, give us a ready method for estimating the amount of aqueous vapor.

TABLE I.

Reading of Dry Bulb Ther.	Factor.	Reading of Dry Bulb Ther.	Factor.	Reading of Dry Bulb Ther.	Factor.	Reading of Dry Bulb Ther.	Factor.
Degree.		Degree.		Degree.		Degree.	
32	3.32	43	2.20	54	1.98	65	1.82
33	3.01	44	2.18	55	1.96	66	1.81
34	2.77	45	2.16	56	1.94	67	1.80
35	2.60	46	2.14	57	1 92	68	1.79
36	2.50	47	2.12	58	1.90	69	1.78
37	2.42	48	2.10	59	1.89	70	1.77
38	2.36	49	2.08	60	1.88	71	1.76
39	2.32	50	2.06	61	1.87	72	1.75
40	2.29	51	2.04	62	1.86	73	1.74
41	2.26	52	2.02	63	1.85	74	1.73
42	2.23	53	2 00	64	1.83	75	1.72

TABLE II.

Temperature, Fahr.	Weight in Grs. of a Cubic Foot of Vapor.	Temperature, Fahr.	Weight in Grs. of a Cubic Foot of Vapor.	Temperature, Fahr.	Weight in Grs. of a Cubic Foot of Vapor.	Temperature, Fahr.	Weight in Grs. of a Cubic Foot of Vapor.
Degree.	Grains.	Degree.	Grains.	Degree.	Grains.	Degree.	Grains.
32	2.13	43	3.20	54	4.71	65	6.81
33	2.21	44	3.32	55	4.87	66	7.04
34	2.30	45	3.44	56	5.04	67	7.27
35	2.39	46	3.56	57	5.21	68	7.51
36	2.48	47	3.69	58	5.39	69	7.76
37	2.57	48	3.82	59	5.58	70	8.01
38	2.66	49	3.96	60	5.77	71	8.27
39	2.76	50	4.10	61	5.97	72	8.54
40	2.86	51	4.24	62	6.17	73	8.82
41	2.97	52	4.39	63	6.38	74	9.10
42	3.08	53	4.55	64	6.59	75	9.39

Table I gives the factor by which to multiply the excess of the reading of the dry thermometer over that of the wet; to obtain the excess of the temperature of the air above that of the dew point—for every degree of air temperature from 32° to 75° F.

Table II indicates the grains of vapor to saturate a cubic foot of dry air under the pressure of thirty inches of mercury—for every degree of temperature from 32° to 75° F.

Organic Matter. The organic matter of the air is best determined by the process described under the chapter on Water. To apply these tests it is necessary to pass a definite quantity of air through a known quantity of water, to extract from the air all the suspended and soluble organic matter. For the accomplishment of this purpose take a wash bottle and pour into it 500 c.c. of pure ammonium-free distilled water. Fit into the mouth of the bottle a soft rubber stopper, perforated by two glass tubes. One of the tubes, extending from well down in the water, is, just without the bottle, bent almost at a right angle, and terminates in a dilated, funnel-like manner. The other tube, extending from just within the bottle, is also bent at a right angle after leaving the bottle, and the outside end, by means of rubber tubing, is connected with an aspirator. In this manner, knowing the capacity of the aspirator, we can measure the quantity of air passing through the water in the wash bottle. Although the amount of air that should be aspirated through the water is not determined by any fixed rule, fifty liters will be found a convenient quantity.

After charging the water with the organic matter of a definite quantity of air we proceed to test for free ammonia by the methods described when considering the presence of organic matter in water.

In each cubic meter of pure air there are, on an average, about .06 milligram of free ammonia, and .08 milligram of albuminoid ammonia.

Another test, not so accurate as the above method, is performed by imbedding a U-shaped glass tube in a mixture of snow or ice and salt. This reduces the temperature of the tube to below the freezing point, and, then, when the air is aspirated through the tube the aqueous vapor, carrying with it most of the organic matter, is precipitated. Pure ammonium-free distilled water is forced to flow through the tube, washing out the precipitated matter. The washing is then tested for ammonia, free and albuminoid, as above.

This method may also be employed for collecting the suspended matter present in the atmosphere.

Suspended Matter in the Air. We find suspended in the air particles of all kinds and descriptions of matter. The quantity of the suspended matter varies greatly in different localities.

It is only in manufacturing districts and in the workrooms of factories that it becomes a question of much moment; but here it is undoubtedly a potent etiologic or predisposing factor in the production of diseases.

A rough but ready means for determining the nature of suspended matters is to collect that which is deposited in sheltered nooks and crevices, examine it microscopically, chemically, and, if necessary, biologically.

For a more accurate examination it will be necessary to employ other methods which do not depend so much upon chance, but are more comprehensive and definite in their results.

A most excellent method is to slowly aspirate large quantities of air through about 100 c.c. of distilled water in four or five wash bottles, the bottles being connected by rubber tubing and communicating one with another. After aspirating the air through the water the bottles are tightly stoppered with soft rubber stoppers and set aside, that the solid matter may be deposited, when the supernatant liquid is siphoned off; or the water may be poured into a conical glass and withdrawn by means of a wick, as described in the chapter on Water. The water which is withdrawn should be examined by the microscope for any matter that may have come over with it. A quantitative examination may be made by measuring the volume of air aspirated through the water and counting the number of particles of matter in an aliquot part of water.

The aëroscopes described under the methods for collecting bacteria may also be employed for collecting and determining the character of the suspended organic matter.

Arsenic in the Air and in Wall Papers. The occupants of a house sometimes suffer from serious disorders which cannot be attributed to faulty sanitary arrangements, impure water, or to irregularities in their manner of living. In such instances suspicion should fall on the wall paper, and it should be analyzed for arsenic. Wall paper of any color may contain arsenic, though the green-colored paper is the one that is, usually, by the public, associated with this poison. It is by the action of the moist paste that arsenical pigment is, in a majority of instances, decomposed and liberated from the wall paper; hence, another reason for dry walls. Arseniuretted hydrogen is the form in which this metal is chiefly found in the air; occasionally, however, arsenious acid and metallic arsenic are discovered.

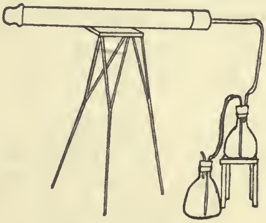
To analyze wall paper and various other materials tear them into small pieces, and treat the pieces according to Reinsch's test, described under the chapter on Water.

Biologic Examination of Air. The air contains, in addition to mineral substances, vegetable and animal débris, certain forms of life. A knowledge of the state and nature of the living organisms of the air is of great moment, not only to the microbiologist but to the sanitarian, and much time and attention have been devoted to its study. In the various forms of bacteria we have the representatives of the vegetable kingdom, and it is with these minute particles of living organic matter that we are particularly concerned. The simplest method for making a biologic analysis consists in pouring glycerin or glycerin and glucose upon a slide and exposing it to the air, and after twelve or forty-eight hours examining it under the microscope and inoculating tubes of nutrient material. Spreading nutrient gelatin in a thin layer upon a slide and exposing it to the air and watching the development of the colonies is another easy method. These colonies may be examined microscopically, and for a more extended observation tubes are inoculated.

Koch's Apparatus consisted of a glass jar, 6 inches high, a shallow glass capsule, and a brass lifter. To prepare the apparatus for use, place the capsule in the jar, plug the jar with cotton wool, and sterilize in the hot air sterilizer. Nutrient gelatin or agar is liquefied in a stock tube and poured into the capsule. When the air is to be examined remove the cotton plug and permit free access of the air for a definite time, then replace the plug and set aside the apparatus for the organism to develop. When wished, the capsule is raised from the jar by the lifter.

Hesse's Aëroscope. A hollow glass cylinder fifty to seventy cm. long and three to four cm. in diameter, with flanged ends, is secured. One end is closed by a caoutchouc stopper, which is perforated in the center to accommodate a glass tube with cotton plug. Placed across the other end is, first, a rubber cap with a hole cut in the center, and over this a second rubber cap. This second rubber cap is removed when the instrument is to be used. The apparatus is washed in 1 per cent. bichlorid solution and then placed in the steam sterilizer. After it has been subjected to the action of the steam for fifteen minutes, it may be removed and when cooled charged with nutrient media, which is set in a thin layer, around the inner surface of the cylinder, somewhat thicker at the bottom.

FIG. 64.

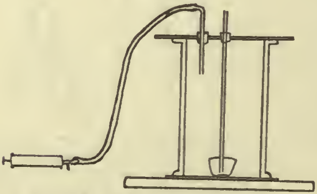


HESSE'S AËROSCOPE.
Showing attached flasks to be used as an aspirator, and by means of which the air is measured, the whole mounted on a photographic tripod.

Connected with the small glass tube by means of rubber tubing is an aspirator, which may be constructed as follows:— Two conical flasks, closed with rubber stoppers, each having two perforations, through which pass glass tubing, arranged as in wash bottles. The long tubes are connected by rubber tubing upon which is a pinch-cock. One of the flasks is filled with water and connected with the apparatus. The latter flask is placed at some little distance above the other. By tipping the upper flask the water flows into the lower one and the flow is continued without interruption by siphonic action. When the water in the upper flask is exhausted, the position of the flasks may be reversed and the action continued indefinitely. This induces a constant flow of air through the aëroscope, and one great advantage of this method is that the quantity of air may be measured. Although the apparatus may rest upon any kind of a stand, a photographic tripod will be found exceedingly convenient.

A simple and efficient means for analyzing air is by forcing it through various media, water, bouillon, liquefied gelatin, or agar, which collects the organisms. An inexpensive apparatus may be made by obtaining a cylindrical bell glass with the top open and provided with a neck, so that a rubber stopper may be adapted to it. The rubber stopper has two openings to admit pieces of glass tubing, one long and the other short. The bottom of the bell glass, which is smeared with glycerin, rests upon a ground glass plate. Within this is a glass capsule filled with media. The long tube, stoppered with cotton when not in use, extends to the bottom of the capsule. The short tube is plugged with cotton and its outer end connected with an air pump or aspirator, by rubber tubing. The air in the apparatus is exhausted and the air to be examined is thus forced through the media. A drop of the media is placed on a slide and examined microscopically. Plates and tubes of nutrient media are also inoculated and the various organisms isolated. (See chapter on Technic.)

Fig. 65.



Simple Form of Aëroscope.

With syringe attached for the evacuation of the contained air. The same aspirating method, by flasks, as shown in Hesse's Aëroscope may be used.

CHAPTER VII.

CLIMATE.*

Although comparatively easy for us to understand what one means when one refers to the climate of a certain locality, nevertheless, when an attempt is made to define it, we find ourselves engulfed in a sea of impossibilities. Parkes' definition, that it is "the sum of the meteorological conditions of a place or region," does not at all cover the requirements, as it neglects to take into consideration the physical conformation of that portion of the earth's surface and the relation to water courses, etc. For the most part, to be specific, it may be said that climate is made up of those influences expressed through latitude and altitude, temperature, barometric pressure, the relation of large bodies of water, contour of the earth's surface in any given area, the amount of moisture in the atmosphere, and, to some extent, is modified by the vegetation on, as well as the composition of, the earth's surface. On account of the varied irregularities of the earth's surface, the presence of mountains and plains, large bodies of water, deserts, of barren areas and of thickly wooded districts, all of the attempts at tracing upon the earth's surface climatologic zones have proven futile.

We are to remember that seasons modify temperature, humidity, etc., to an enormous degree; thus, while it is midsummer in the latitude of Philadelphia, the temperature will be the same as midwinter at some point nearer the equator. While, therefore, the temperature must vary through an enormous range from one season to another, there is a slight element of consistency or regularity following the development or cycle of the seasons, the average of such variations constituting the normal.

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* The writers wish to thank the Hon. Secretary of Agriculture, also the Chief of the Weather Bureau, Mr. Mark W. Harrington, Washington, D. C., and other officers of the Bureau, for many kindnesses and much labor, which they have all given, in the compilation of this chapter, and also for the loan of illustrations freely granted.

Aside from mere altitude, mountainous and hilly districts affect climate by altering and lessening winds, by diminishing the surface evaporation of water, probably, also, by the presence of large quantities of vegetation and the slowness with which the seasons manifest a change.

Relation of Climate to Health. The question of the effect of climate upon health is still a matter of very warm dispute. Does a man adapt himself to a climate? The question must of necessity, for the present at least, remain *sub judice.* In the first place, it is impossible to remove a man from a temperate climate to a tropical, for example, and not demand that his food be changed, his habits modified, and even his occupation more or less altered. It would seem that man rapidly adapts himself to changes in temperature, provided the change be one sufficiently gradual to permit a modification of habits and food. Changes in humidity are not so readily borne as are those of temperature, and the same is true of barometric pressure. For this reason, if for no other, the sick should not be allowed to travel over routes where constant changes in altitude occur. Reference has already been made to caisson disease when considering the causes of disease.

Climate is a matter of more importance in the therapy of disease than in the study of hygiene. As a general rule, it may be considered that acclimatization is possible, indeed, probable, in the sense that the body accommodates itself to the change in temperature, changes in diet, habits, and environment. It would therefore appear that that temperature or that climate to which an individual has been longest accustomed is, taken all in all, the best for that individual under most circumstances. If there be individual objections to the climatologic surroundings, he may move, but an entire change is something rarely, if ever, to be advised. Even the removal from malarial districts, in individuals who are accustomed to those areas, is a matter not often to be commended. The writers have observed that students coming from malarial localities of the South suffer a very little less as a result of three years residence in the city of Philadelphia, and that sailors embarking from malarial climates not infrequently continue their manifestations of the disease until it be controlled by properly directed medical efforts, returning after a season of apparent abeyance. The spread of malaria and the removal of malarial influences are best secured by higher altitudes and proper drainage.

Many erroneous observations have been made with regard to consumption, based upon its absence from certain areas, the fact being that it is absent merely because the area has not been infected by tubercular cases, and hardly because the atmosphere and climate is not suitable for the development of the disease. We are informed, upon the authority of credible witnesses, that in certain districts in North Carolina and South Carolina tuberculosis among the inhabitants was long unknown; as a result of this fact, patients sought these areas under the impression that what would prevent a disease, for that was the way that the facts were viewed, would be sure to cure it. The disease is no longer unknown among the inhabitants, and the benefit probably derived by the patients would be equally sure to have followed a sojourn elsewhere, provided the atmosphere had been equally clear from impurities, more especially those resulting from the inroads of civilization.

That certain climates are conducive to the development of definite groups of disease is abundantly proven. Where heat, moisture, and suitable telluric conditions are present, diseases, parasitic, both animal and vegetable, thrive to the greatest extent. Pollution of the necessities of life, water, food, etc., strangely becoming a part of the climate itself, facilitate the endemic presence of all such diseases, and render the difficult process of suppression, in no few instances, impossible. Habits of the people, combining with the other etiologic factors, aid in the strongest possible way. As examples of this, we have the endemic presence of cholera in certain countries and of smallpox in others, both diseases similar; but identical climatologic conditions can be found elsewhere without these dread diseases, lacking the third factor, habit and environment.

Race seems more influenced by the climate than does the individual, the Caucasian thriving to the best advantage in the temperate zone, and the colored races evincing a predilection for the tropical belts.

Sex apparently is but little influenced by climate; the woman enjoys better health in warm climates, while man seems to be more susceptible to the inroads of heat. This may be partly explained by the occupation demanding greater exposure to the noxious agents.

The integral elements of which the complex entity, climate, is composed seems to afford more noxious features than does the whole. Thus, as already pointed out, heat and moisture increase the "filth diseases," and to a certain extent heat and a dry atmosphere, particularly the latter, lessen the liability.

Sudden Changes of Temperature, more particularly from warm to cold, and worse if the former have a high relative humidity, are potent factors in establishing diseases of the mucous membranes. This is probably brought about by chilling of the surface of the body, contraction of the cutaneous capillaries, and visceral determination of the blood; the mucous membrane, constituting the great area of the internal blood-receiving organs, suffers to the greatest degree. As examples of this, we have the catarrhal conditions of various mucous surfaces manifested during the seasons when sudden changes are most likely to occur. There can be no doubt that the exacerbations of rheumatism and gout, during just such changes, as well as from altered barometric pressure, are not explained exclusively by the meteorologic phenomena. A hot bath may accomplish the same thing, but it produces no such disease phenomena as neuralgic attacks or rheumatic sufferings. From observations carried on at the Pennsylvania Hospital, and quoted in Prof. Longstreth's lectures, it would appear that sudden variations in pressure determine a fatal issue in pending cases.

For reasons already given, diseases of the mucous membranes can best be treated in an atmosphere least likely to afford sudden changes and, also, where the relative humidity would remain low. Sudden changes from warm to cool seem to influence the gastro-intestinal track, while the reverse affects more the pulmonary.

Season, for reasons already given and from causes but little understood, alters the tenure of life in those already greatly depressed, and possibly affects more or less remotely those in health. The influence of season in determining mortality is illustrated by the following table from Wilson :—

	WINTER.			SPRING.			SUMMER.			AUTUMN.		
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Smallpox,	+	+	+	+	‡	+	—	—	=	—	—	—
Measles,	+	—	—	—	+	‡	+	—	—	—	+	‡
Scarlatina,	—	—	—	—	—	—	—	+	+	‡	+	+
Diphtheria,	+	+	—	—	—	—	—	—	+	+	‡	‡
Croup,	+	+	+	+	—	—	—	—	—	—	+	+
Whooping cough,	+	+	+	+	+	—	—	=	=	=	—	+
Typhus (6 yrs.),	+	+	+	+	—	—	+	—	—	+	—	+
Typhoid (6 yrs.),	+	+	—	—	—	=	—	+	+	+	‡	+
Simple continued fever,	+	+	‡	—	—	+	—	—	+	—	—	+
Erysipelas,	+	+	—	—	—	—	—	—	—	+	‡	‡
Diarrhea,	—	—	—	—	—	—	‡	‡	+	—	—	—
Rheumatism,	+	+	+	+	+	—	—	—	—	—	+	+
Gout,	+	+	+	+	+	—	—	—	—	—	—	—
Phthisis,	+	+	+	+	+	—	—	—	—	—	—	+
Heart disease,	+	+	+	+	—	—	—	—	—	—	+	+
Bronchitis,	‡	+	+	+	—	—	—	=	—	—	+	+
Pneumonia,	+	+	+	+	—	—	—	=	—	—	+	+
Pleurisy,	+	+	+	+	—	—	—	=	—	—	+	+
Old age,	‡	+	+	+	—	—	=	—	—	—	—	+

+ Above the average.
— Below the average.

‡ Maxima.
= Minima.

Climatologic Observations. Among the elements which enter into the study of climate are *temperature*, *barometric pressure*, *precipitation* (*rainfall* and *snowfall*), *wind*, the consideration of both direction and velocity, *sunshine* and *cloud*, *electrical phenomena*, *moisture* in the air, and *vapor pressure*, including the *dew point*, *evaporation*, the presence or absence of *fog*, *haze*, *cloud*, etc.

Temperature is estimated by the thermometer. In the United States, the Fahrenheit scale is the one adopted as the Government standard. The fixed points upon the Fahrenheit thermometer are taken as 32 degrees for the freezing point and 212 degrees for the boiling point under a standard barometric pressure of 29.922 inches. The mercurial thermometer is reliable between minus 37 degrees and plus 400 degrees. It is to be remembered that thermometers change slightly with age, and that extremely high temperatures, or the reverse, modify the readings, and it is therefore necessary, at varying intervals of one or not more than two years, to compare all thermometers with a standard thermometer in order to observe any correction necessary in their readings. Thermometers may be made with either spherical or cylindrical bulbs; the latter expose more surface and are therefore generally admitted to be the more satisfactory instruments. For taking temperatures below the freezing point of mercury, alcohol thermometers are the most desirable.

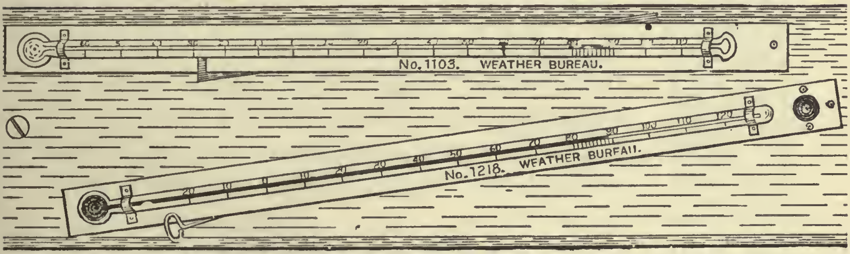
Minimum thermometers are used for reading the lowest temperature during the day. A small index made of enamel or glass is fitted loosely in the bore of the stem, immersed in alcohol. When the temperature falls, this index is carried along by the film or "skin" covering the end of the alcohol column and stops at the lowest point reached. Should the temperature rise, the alcohol will flow by the index and leave it at the lowest point. The instrument is to be set after each observation. The setting consists in raising the bulb high enough for the index to sink by gravity to the end of the column of alcohol. Care must be taken that the index remains within the alcohol and does not break through the film into the vacuum above the end of the column, otherwise errors in observation are likely to occur.

Maximum thermometers are used for recording the highest temperature reached in any given time; they consist of an ordinary thermometer with a contraction in the stem near the bulb, so arranged that when the temperature rises the mercury is forced into the tube, but when it falls the contraction in the stem breaks the column of mercury and leaves the remainder of the column as an index.

Following the plan adopted by the United States Department of Agriculture (Weather Bureau), the accompanying illustration will show how the two thermometers should be set up. The maximum thermometer is set up by placing it in an almost horizontal position with the bulb lower than the upper extremity. The minimum thermometer is set up by placing it nearly horizontal. Thermometer readings are taken in the shade, at a greater distance than four feet above the ground and in the absence of wind; thermometers should not be in the immediate proximity of a wall upon which the sun is shining. Rain should be excluded.

The mean temperature of the day is obtained by taking the temperature at 7 A. M., 2 P. M., and 9 P. M., when observations of a dry thermometer are made at such hours, from the following formula, which gives a very close approximation to the true mean for the day.

Fig. 66.



Showing Maximum and Minimum Thermometers and Method of Setting Them Up. The upper instrument is the minimum thermometer.

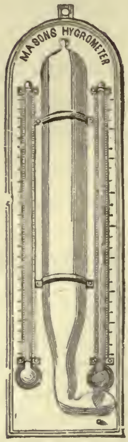
$$\frac{7\text{ A. M.} + 2\text{ P. M.} + (9\text{ P. M.})}{4}$$

When readings are made twice each day at the same hours, the mean is then obtained by dividing the sum of the readings by two. The method now in use in the United States Weather Bureau is to divide the sum of the highest and lowest daily temperature of the day by two, which gives, on the average, a mean about one degree too high.

It is not deemed necessary to describe the solar radiation thermometer, as, so far as known, no practical knowledge has been derived from its readings.

The *thermoscope* consists of a glass tube containing an alcoholic solution of camphor; when the temperature is high the camphor is all in solution; when the temperature is low, it crystallizes in fleecy clouds. The instrument is often sold mounted with a thermometer and is presumed to indicate some changes in barometric pressure, approach of storms, or electrical conditions of the air, etc., but it possesses no such value.

Fig. 67.



Hydrometer or Thermoscope.
An instrument widely used, but possessing no reliable features in weather prognostication.

Aqueous Vapor. Air always contains more or less vapor of water, which at times becomes visible as fog or cloud, or when the temperature of the air is near the saturation point,—that temperature at which evaporation ceases,—it manifests itself by condensing into vapor on exposed bodies. The quantity of moisture which any given volume of air will take up is dependent upon the temperature, and if saturation occur at a higher temperature and the temperature falls, the moisture will be precipitated. The point at which this precipitation takes place is known as the *dew point*, or *point of saturation.*

For different saturation temperatures the vapor pressures in inches of mercury, and weight of the vapor in grains contained in a cubic foot of air, are as follows:—

Temperature of saturation, degrees	*Vapor pressure in inches.*	*Weight in a cubic foot, grains.*	*Temperature of saturation, degrees.*	*Vapor pressure in inches.*	*Weight in a cubic foot, grains.*
0	0.038	0.56	60	0.517	5.74
10	0.063	0.87	70	0.732	7.98
20	0.103	1.32	80	1.022	10.93
30	0.164	1.96	90	1.408	14.79
40	0.246	2.85	100	1.916	19.77
50	0 360	4.08			

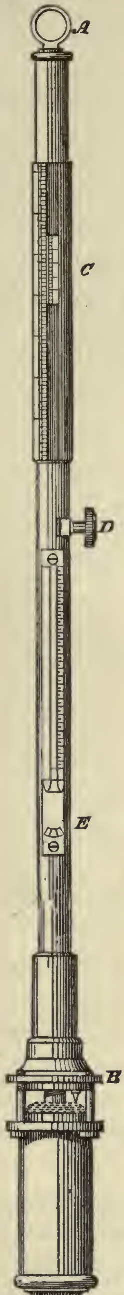
The *relative humidity* is calculated by taking the pressure of the vapor as found in a given temperature and dividing by the amount of vapor which would be contained in air saturated at that temperature, the result being the relative humidity, expressed in hundredths of the pressure at saturation. Should the temperature rise or fall, the percentage of relative humidity will change, although there may be no change in the absolute humidity in the atmosphere, and for this reason relative humidity is a constantly changing element.

Psychrometer. This instrument consists of two thermometers, one known as the dry-bulb and the other as the wet-bulb thermometer. The dry-bulb is nothing more nor less than an ordinary mercurial thermometer and the wet-bulb is a similar instrument, in which the bulb is covered by a layer of muslin kept saturated with water. As the evaporation of the water from the muslin over the bulb cools the mercury within the bulb, the wet-bulb thermometer will read lower than the dry-bulb, and as the lower the amount of water in the air at a given temperature the more rapid will be the evaporation from the wet-bulb, so that the reading of the wet-bulb will be lower the dryer the air. By a system of comparisons between the different portions of the apparatus and different observations, tables have been constructed by means of which, given the readings of the dry- and wet-bulb thermometers, the temperature of the dew point and the relative humidity may readily be obtained. (See Glaisher's tables in chapter on Air.) The accuracy of the dry- and wet-bulb thermometers and the certainties of their readings may be developed to a higher degree by the *sling thermometer*, which consists of a dry- and wet-bulb, mounted either back to back or side by side in such a manner as to enable the observer to sling them readily, thus bringing the bulb in contact with constantly changing air and preventing the accumulation of the saturated air immediately around the wet-bulb. The thermometer is whirled about fifty revolutions; both thermometers are then read and the wet-bulb re-moistened and whirled fifty revolutions and again read; this process is repeated until two readings of the wet-bulb are the same or a reading is reached in which the wet-bulb records higher than in the previous reading. The lowest simultaneous reading should be recorded.

Barometer. The mercurial barometer consists of a glass tube about thirty-eight inches in length and one-quarter of an inch in its interior diameter, sealed at one end, filled with mercury, and inverted, the open end dipping into a cistern of mercury. The vertical height from the level of the mercury in the cistern, when adjusted to the zero point of the scale, to the top of the mercury in the inverted tube is known as the barometer reading; above this point is the vacuum chamber of the barometer. For convenience and to prevent breakage, the entire instrument is enclosed in brass, with the exception of the cistern and the upper part of the tube, which are left exposed in order that the mercury may be seen and its height regulated in the cistern and that readings may be made from the upper column. The accompanying illustrations will best explain the essential features of a modern barometer.

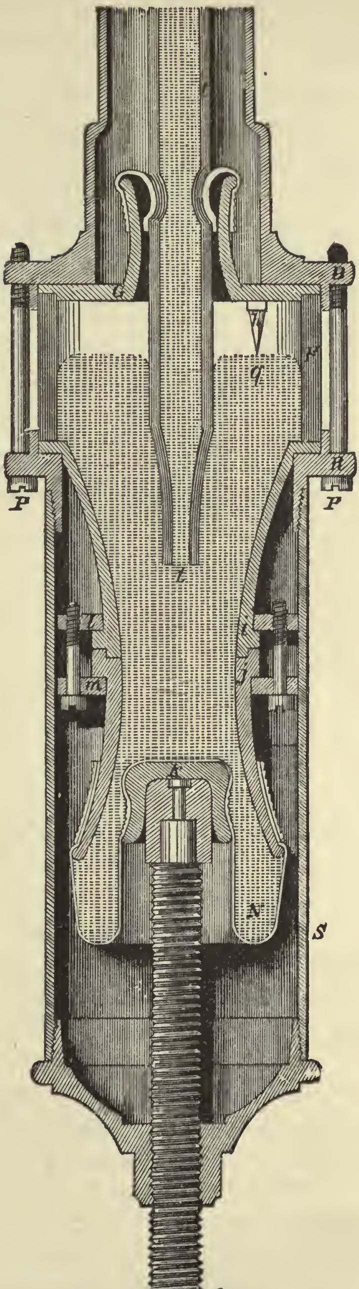
To facilitate reading there is attached the vernier, so named from its inventor. For convenience the vernier is usually arranged on a rack and pinion, so as to be moved by a thumbscrew, as shown in the illustration. As the mercury within the barometer is affected by heat and cold it is important that we should have a record of its temperature in order that the necessary corrections may be made; for this purpose a thermometer is placed with the bulb resting against the glass barometer tube. For observation, the barometer should be placed in a room having a temperature as uniform as is attainable, and the height should be such that the top of the column would be about on a line with the observer's eye. Care must be taken to protect the instrument from air currents or direct rays of the sun, and at the same time it must be in such light as to secure plenteous illumination to facilitate reading. The instrument must hang vertically, or "plumb." Certain barometers are so constructed as to always assume a vertical position by means of a ringed suspension apparatus at the top. The barometer should be surrounded by a box to prevent sudden variations in temperature and to exclude dust. In order to make an observation and to correct it, as is now directed by the Weather Service, the observer will proceed in the following order: First note the temperature of the attached thermometer, then gently tap the instrument at several points in order to loosen up any cohesion between the mercury and the glass. By means of the screw (*O*) at the bottom of the cistern, lift or depress the mercury in the cistern until the ivory point, *q* (the zero of the scale), comes in exact contact with the surface of the mercury. This can be easily determined; as one looks at the mercury the inverted point will be observable, and when the inverted image and the point are in exact contact the desideratum has been attained. If the surface of the mercury be covered by a layer of the oxid, some difficulty may be found, but this can usually be remedied by noticing that as soon as the ivory point impinges upon the surface of the mercury a slight indentation will be discernible,

Fig. 68.



Barometer, as Supplied by Weather Bureau. A, ring for suspending the barometer. B, top of cistern. C, vernier and scale. D, vernier rack and pinion. E, attached thermometer.

Fig. 69.



Barometer, showing arrangement for regulating the height of mercury in the cistern.

and the mercury may be slightly raised and then lowered until this depression disappears. The vernier is then adjusted until the reading plane of the vernier is tangent to the meniscus (rounded top) of the column of mercury. The reading of the instrument is accomplished as follows: The inches and tenths of inches are read on the barometer scale and the hundredths and thousandths of inches on the vernier; a line on the vernier is found which coincides with a line on the barometer scale; this is then taken as hundredths, the thousandths being interpolated when such fractions occur.

FIG. 70.

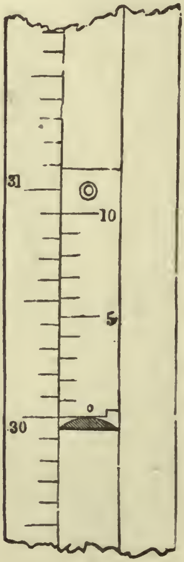


FIG. 71.

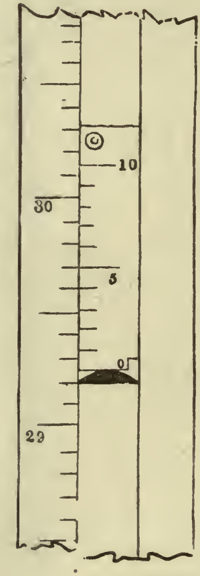
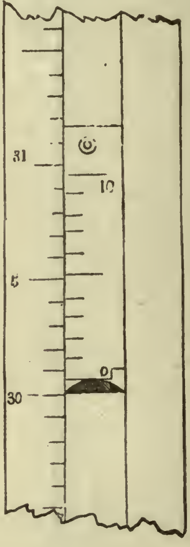


FIG. 72.



The following examples, taken from the "Instructions for Voluntary Observers," issued by the United States Weather Bureau, will more fully explain the method:—

In Fig. 70 the regulating line, which is the lower edge of the vernier ring, coincides exactly with the line of 30 inches on the scale. The zero and tenth division of the vernier are also in exact coincidence; that is to say, there is no fraction. We then shall read 30.000 inches.

In Fig. 71 the regulating line does not fall upon any of the divisions of the scale, but between $29\frac{2}{10}$ and $29\frac{3}{10}$ inches. There is then a fraction which must be read on the vernier. Seeking which of these divisions coincides with that of the scale, we find that it is the fifth; we shall write, then, 29.250 inches.

In Fig. 72 we see that the height falls between 30 inches and $30\frac{1}{10}$ inches; no line of the vernier coincides exactly; but the line 7 is a little above and the line 8 a little below one of the lines of the scale; the fraction falls, then, between seven and eight hundredths. Estimating in tenths the distance the vernier passes over between the coincidence of 7 and that of 8, the tenths of a hundred or the thousandths are obtained. In the latter case the distance above 7 is greater than the half; it will read, then, greater than 30.075 and less than 30.080, or about 30.077. It will always be easy to judge whether the top approaches nearer the upper coincidence than the lower coincidence; in the former case the fraction is greater than .005; in the latter it is smaller than .005. The error which will be committed in this estimate will remain less than .005; after a little practice it will rarely exceed .002, always supposing the scale is well graduated. For this reading, as well as for the others, it is particularly important to have the eye exactly at the height of the line to be determined.

Corrections. Having taken the reading, certain corrections will be found necessary. First, the instrument should have been compared with a standard barometer and corrections made for instrumental error; these corrections are now made. Next, the corrections must be made for temperature, and this is usually done by tables. The correction for temperature consists in reducing all observations to a temperature of 32 degrees F., and this is computed from the following formula:—

$$\text{Correction} = -h\,\frac{m\,(t-32) - s\,(t-62)}{1 + m\,(t-32)}$$

in which

h = reading of the barometer,
t = temperature of attached thermometer,
m = expansion of mercury for 1° F., taken as .0001010 of its length at 32°,
s = expansion of the substance of which the scale is made; for brass s is taken as .00001020 of its length (h) at the standard temperature for the scale, viz.: 62° F.

As it is desirable that all barometers should be read from the same standard, the reading is then reduced to sea level, the reduction being known as the corrected reading.

The correction for altitude consists in reducing the observation to a reading at the sea level, and is computed from the following formula :—

$$\text{Log. } \frac{h}{h'} = f \div \left\{ 60159 \left(\frac{1 + t + t' - 64^\circ}{900} \right) \left(1 + .00260 \cos 2l \right) \left(1 + \frac{f + 52251}{20886861} \right) \right\}$$

From a table of common logarithms, the natural number corresponding to log. $\frac{h}{h'}$ is found; or $\frac{h}{h'} = n$, and $h = n\,h'$. In this formula—

h and h' = barometer reduced to 32° F., at sea level and upper station, respectively,
t and t' = the temperature of the air at the respective stations,
f = elevation of upper station in feet,
l = latitude of the place.

Thus the reduced and corrected reading would be as follows :—

EXAMPLE OF CORRECTED BAROMETRIC READING.

Time 8 A. M.

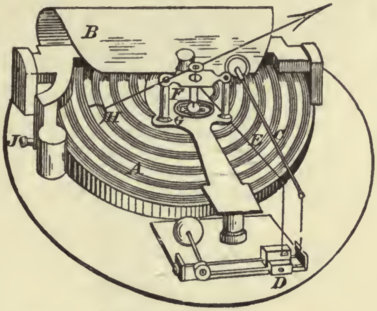
Attached thermometer, ...	70.5° F.
Observed height, ...	29.907 inches.
Correction for ins. error, ...	00.000
Corrected for ins. error, ...	29.907
Correction for temperature, ...	.113
Cor. for ins. error and temp., ...	29.794
Correction for elevation, ...	+.120
Corrected and reduced, ...	29.914

These corrections are demanded in order that observations at different points may be used for comparison.

The altitude of a station may be obtained by taking the difference in the barometric pressure from that at the sea level, dividing this by the pressure of the elevation to be measured plus 30, and multiplying by 55761. Thus the altitude of Pike's Peak would be obtained by adding 17.8 to 30 and using as a fraction the difference between 17.8 and 30, which would be 12.2; the reduced formula would therefore be 12.2 divided by 47.8, multiplied by 55761, which is equal to 14,231.88003.

The *aneroid barometer* will be best understood by referring to the accompanying illustrations. These barometers are graduated by a standard mercurial barometer, and in the best forms there is a correction for temperature, which is necessary by reason of the effect of heat and cold upon the transmitting levers. The instrument is not as accurate as is the mercurial barometer, and is more liable to deterioration.

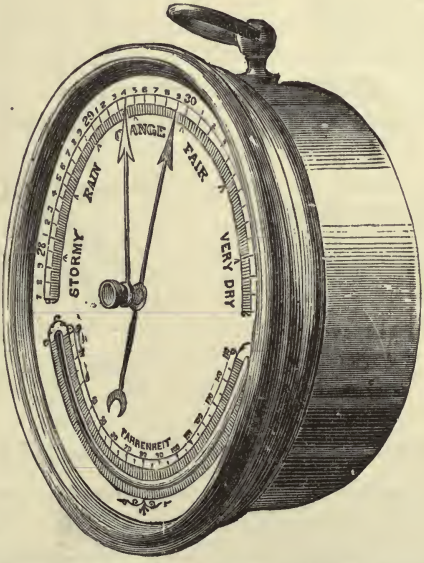
FIG. 73.



ANEROID BAROMETER.
A.—Partly exhausted metallic box, in which the sides are held apart by the spring. B.—E, C, D, the lever mechanism through which the dial-hand, H, is moved.

In estimating altitude, the boiling point of water has been utilized to an advantage; thus, at or near the sea level with a pressure of 29.922, the temperature at which boiling occurs is 212° F., while at a pressure of eighteen inches the boiling point is 187.5° F. A thermometer graduated for obtaining the boiling point is known as the *hypsometer*, and is made very short

FIG. 74.



CASED ANEROID BAROMETER WITH INDEX HAND, AS USUALLY SOLD.
The short hand can be set at any point and is used to locate changes which may have occurred between the readings.

and graduated at the freezing point; a distention then takes place in the capillary tube followed by a contraction and graduation

Fig. 75.

Front View.

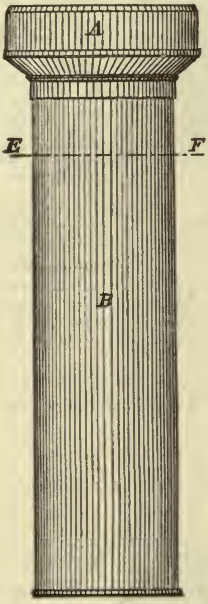


Fig. 76.

Vertical Section.

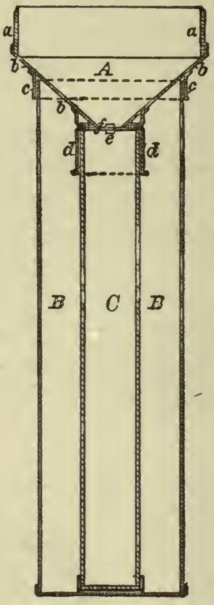


Fig. 77

Receiver.

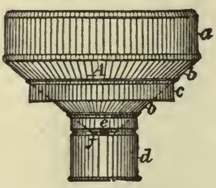


Fig. 78.

Horizontal Section, E-F.

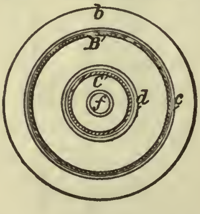
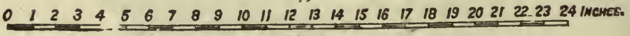


Fig. 79.



SCALE.

Fig. 75 shows Rain Gauge set up. Fig. 76 shows vertical section of same. Fig. 77 shows Receiver and Funnel conducting Tube. Fig. 78 shows horizontal section of 75 at E E. Fig. 79, Scale. A, Receiver. B, Overflow Attachment. C, Measuring Tube. *a*, *a*, Receiver Top, eight inches in diameter, terminating in the funnel-like bottom, which conducts the rain into the Measuring Tube C. *e*, Overflow, opening into outside cylinder. The outside cylinder B, or Overflow Attachment, is used in the winter as a snow receiver; the snow is melted and measured in the Measuring Tube, which for this reason is kept in the house.

from 170° F. to 214° F. The instrument affords a reading which is accurate within about .06 of an inch.

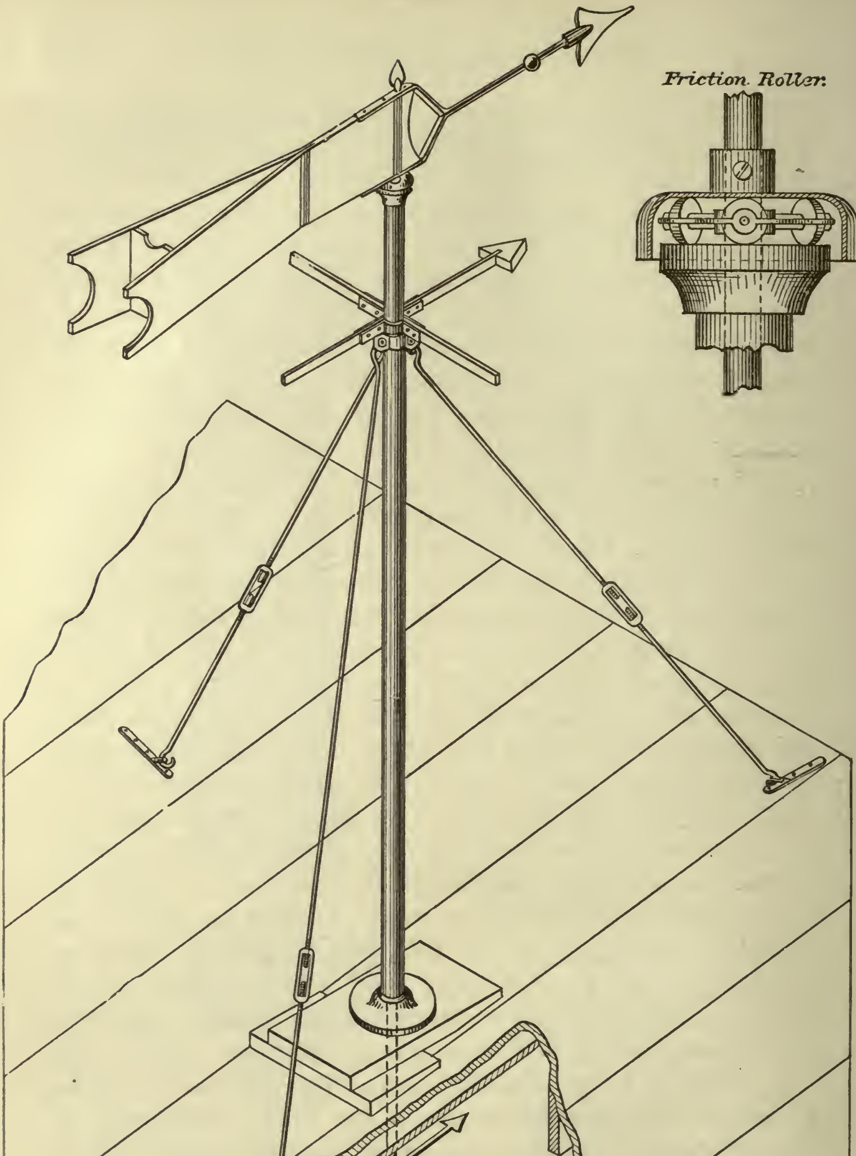
Precipitation. Rain, hail, and snow are all classed under the head of precipitation, and the amount which falls at any time is known as the precipitation for that period; in the annual precipitation the three are included. Hail and snow are measured as the depths of water which they produce when melted. When snow cannot be melted and measured, one-tenth of the measured depth may be considered as its equivalent in rainfall; there are, however, a great many factors which modify this and render the method inaccurate. The instrument used for obtaining the amount of precipitation is known as the *rain gauge*, and reference to the accompanying illustrations will explain its parts.

A rain gauge should be preferably located in a large open space and within a very few feet of the ground. Altitude affects materially the amount of rain which a gauge will collect; thus a gauge forty-three feet above the ground will collect only about three-fourths as much as will that upon the ground; at eighty-five feet not quite two-thirds, and at two hundred feet about one-half. In the city, a roof at least fifty or sixty feet square, if not too elevated, will give practically the same results as the open plain. The depth of water in the rain gauge is measured by inserting the gauge stick through a hole in the funnel and observing to what point the stick is wetted. As the stick is graduated to allow for the cylinder containing the water being one-tenth the diameter of the collecting funnel, the reading off may be in decimals, as graduated on the stick. During the winter the snow-fall is received in the outside cylinder; the overflow attachment receiver and measure top may be kept in the house. The snow-fall collected in the overflow top is melted, poured into the measure cylinder, and estimated as already directed for rain.

A *percolation gauge* is used to determine the amount of rainfall which penetrates the surface of the earth. The gauge as ordinarily used consists of a metallic receptacle three feet in diameter and about three feet deep, at the bottom of which on one side there is a depression which receives any water which flows through. This is to be pumped out and measured. The surface percolation depends largely upon the amount of rainfall, the temperature, and character of the soil.

Wind. The direction of the wind is measured by a wind vane and is always considered to be the point of the compass from

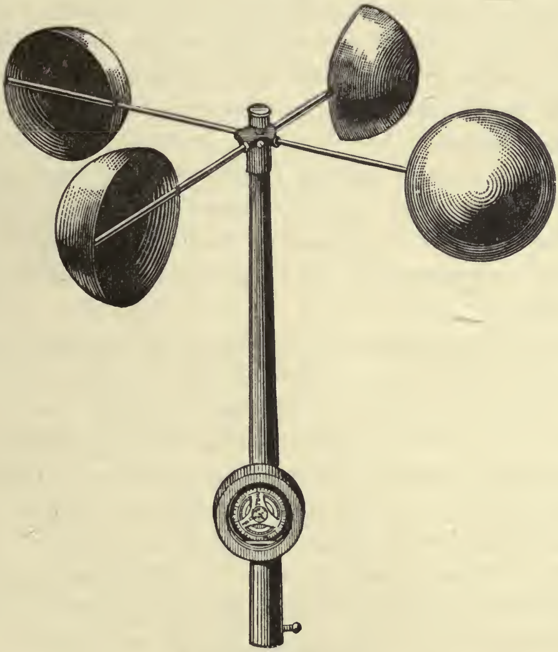
Fig. 80.



Wind Vane and Ceiling Dial.

which the wind is coming. The accompanying illustration shows the form of wind vane as recommended by the Weather Bureau. The recommendation is made that the vane be not less than eight or ten feet above the top of the building upon which it is mounted. Where there are rapid changes in the direction of the wind, those made in the direction in which the hands of a watch move are known as *veering*, while those made in the opposite direction are known as *backing*.

FIG. 81.



ROBINSON ANEMOMETER.

Anemometer. For measuring the velocity with which the wind travels, some form of the anemometer is used. The one recommended by the Weather Bureau is known as the Robinson Anemometer; other forms are used for measuring air currents in mines and for studies in ventilation, etc.*

In the Robinson Anemometer the reading of the dial is to be

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*For measuring, heating and ventilating currents, see *Anemometer*, under Ventilation and Heating.

corrected, and for this purpose the accompanying table is compiled.

Observed velocity, miles per hour.	*True velocity, miles per hour.*	*Observed velocity, miles per hour.*	*True velocity, miles per hour.*
0	. .	50	40.8
10	9.8	60	48.0
20	17.8	70	55.2
30	25.7	80	62.2
40	33.3	90	69.2

The wind pressure in pounds per square foot is equivalent to 0.004 multiplied by the square of the true velocity.

Clouds. For convenience in observation, clouds are divided into three primary types and three compound or secondary: *Cirrus*, *Cumulus*, *Stratus*, *Cirro-cumulus*, *Cirro-stratus*, *Cumulo-stratus*, and *nimbus*.

The *cirrus* clouds are the high whispy or feathery clouds, whitish in color and sparsely present. They are sometimes known as "cat's whiskers" and as "mare's tail" clouds. They are clouds of extremely high altitude, rarely if ever below 16,000 feet.

The *cumulus* is a dense compact cloud, round in the foreground and bulging "like cotton from a bale." It has a flat surface toward the earth, and is usually about 4000 feet above the ground surface. It is due to a condensation of moisture in the ascending columns of air after reaching a sufficiently high altitude to attain the dew point. The cumulus forms one of the varieties of "thunder heads" as observed at sea.

Stratus. While cirrus and cumulus are distinctly day clouds, the stratus is a night cloud and is formed largely by the radiation of heat from the lower layers of the atmosphere. It consists of an elevated fog, about one to two thousand feet in altitude. The mass is uniform, covers a large area, and appears, as the name indicates, in strata.

Of these three primary forms there may be various combinations, the *Cirro-stratus*, *Cirro-cumulus*, *Cumulo-stratus*, the latter being sometimes called the "roll cumulus."

The *nimbus* is a dense, thick, black cloud, without any apparent margin, and from which rain or snow is constantly falling.

Besides observing the character of the cloud, that is, to which of the preceding groups it belongs, its direction, rapidity of movement, elevation, and proportion of the sky which it covers should be noted.

In recording weather observations, the sky is accorded clear when less than .3 obscure, it is fair when from .4 to .7 obscure, and cloudy when the sky is more than .7 obscure.

The *evaporometer* is an instrument from which measurement is made of the amount of moisture which evaporates in a given length of time; usually it consists of a round dish, one foot in diameter and about four inches in depth, and the amount of radiation is known by measuring the depth of water or by weighing the dish. The dish should be kept in the open air, free from the influence of the sun's ray and winds. " With a wind velocity of five miles an hour, the evaporation is twenty-two times as great as in a calm. Ten miles an hour 3.8 ; fifteen miles 4.9; twenty miles 5.7 ; twenty-five miles 6.1 ; thirty miles 6.3."

The following data, collected from various sources credited with each item, are inserted that medical men may have some references to which they may turn when a change of climate in any case may seem desirable. Unlike faulty drainage or poor water, no sanitary laws can alter an undesirable climate, and hence where a change is demanded, either in the treatment or prevention of disease, the individual must seek the desired region. Where the climate of a single State varies greatly it is necessary to record the variations, as serious errors might otherwise arise. For example, one given the indefinite directions to visit California might encounter any climate, either wet or dry, warm or cold, or any combination of the four factors, and of course any barometric pressure, from sea level to perpetual snow altitude.*

MICHIGAN.

Mr. Edward A. Evans, Local Forecast Official at Detroit, Mich., supplies the following data compiled from twenty years' observation :—

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*These data have been collected under the greatest possible difficulties, as all attainable records are made with the agriculturist's interests at heart and with almost no consideration for their sanitary importance. It has been in this that the officers and representatives of the Federal and State Weather Services have given us the greatest possible aid. Several States have been left out of the data, either because approximate data were inserted from adjoining States or by reason of such faulty records as to offer no data of value.

Temperature by months (degrees F.): January 24.8; February 26.5; March 32.5; April 45.1; May 57.7; June 67.3; July 71.8; August 69.6; September 62.3; October 51.2; November 38.3; December 29.4

Precipitation, in inches: January 2.04; February 2.29; March 2.42; April 2.20; May 3.46; June 3 69; July 3.55; August 2.94; September 2.59; October 2.61; November 2.54; December 2.45.

Humidity (per cent.): January 77.8; February 75.8; March 73.7; April 65.6; May 64.5; June 68.4; July 69.2; August 70.6; September 70.8; October 71.7; November 74.5; December 78.3.

The actual mean annual barometric reading is 29 inches.

The average date of the last killing frost in the spring is April 28, and of the first killing frost in the fall, October 25.

MISSISSIPPI.

From Mr. R. J. Hyatt, Local Forecast Official at Vicksburg, Miss., the following data have been received:—

Mean Temperature by months (degrees F.): January 47.6; February 52.9; March 58.3; April 65.9; May 72.9; June 79.3; July 91.7; August 80.2; September 74.9; October 65.6; November 55.3; December 50.5; mean annual 65.2 F.

The *mean precipitation* by months is: January 5.47 inches; February 4.85; March 6.38; April 6.42; May 5.15; June 4.33; July 4.12; August 3.64; September 4.08; October 3.00; November 4.36; December 5.08. Average monthly 4.74 inches.

Mean Relative Humidity (per cent.): January 74.6; February 71; March 65.9; April 67.9; May 70; June 74.7; July 76.6; August 75.3; September 75.1; October 74.1; November 71.3; December 71.8.

Above data compiled from eleven years' records.

MINNESOTA.

From Mr. Edward A. Beals, Director of the Weather Bureau of Minneapolis, Minnesota, the following data have been received:—

The *temperature* by months (degrees F.): January 7; February 11; March 24; April 44; May 54; June 65; July 70; August 66; September 58; October 45; November 29; December 18; mean annual temperature 41.

The *precipitation* by months is: For January 1.15; February 0.95; March 1.11; April 2.40; May 2.93; June 4.21; July 3.52; August 2.93; September 2.46; October 1.33; November 0.80; December 1.22; mean annual 25 inches.

No data were obtainable as to relative humidity and average atmospheric pressure.

The humidity and pressure from four selected Weather Bureau stations for a period of from seven to ten years ending December 31, 1881, are as follows:—

	Pressure.	*Relative Humidity.*
St. Paul,	29.942	68.5
Moorhead,	29.971	74.5
Duluth,	29.974	70.2
St. Vincent,	29.963	76.2

Above data compiled from seven years' observations.

KENTUCKY.

From Mr. Frank Burke, Local Official of the Weather Bureau, at Louisville, Ky., the following data have been obtained:—

Average temperature by months: January 34.2; February 38.7; March 44.2; April 55.8; May 66.4; June 74.7; July 78.9; August 76.4; September 68.7; October 58.4; November 45.3; December 37.9; annual average 56.6.

Precipitation (in inches): January 4.26; February 4.51; March 4.08; April 4.52; May 3.95; June 4.46; July 4.14; August 3.57; September 2.90; October 3.32; November 3.89; December 4.30; annual average 47.90. Highest temperature recorded in past 21 years 104.6° F. Lowest temperature—19.5° F. Average date of first autumn frost October 6; average date of last spring frost April 20. Mean annual humidity 66 per cent. Mean annual barometric pressure 29.488, without correction.

Prevailing direction of wind, south.

Annual average number of clear days,	110
" " " cloudy days,	120
" " " partly cloudy days,	135
" " " days with .01 or more of precipitation,	130

Above data determined from twenty-one years of observation.

WASHINGTON.

Mr. H. F. Alciatore, Director of the Weather Bureau at Olympia, Wash., kindly supplies the following data compiled from official records for a period of fifteen years.

Temperature by months (degrees F.): January 37.8; February 39.5; March 44.7; April 49.3; May 54.7; June 59.5; July 62.5; August 61.6; September 56.9; October 51.0; November 45.2; December 41.0; mean annual 50.3.

Highest temperature on record, 97° on July 27, 1885; lowest temperature, 2 degrees below zero on January 15, 1888.

Precipitation in inches: January 8.53; February 7.33; March 5.20; April 3.32; May 5.47; June 1.51; July 0.82; August 0.72; September 2.82; October 4.51; November 6.21; December 9.74; mean annual precipitation 56.

Relative humidity (per cent.): January 87; February 86; March 83; April 79; May 74; June 73; July 71; August 75; September 80; October 86; November 88; December 89; mean annual 81.

Mean annual barometric pressure reduced to sea-level and corrected for temperature, 29.99 inches. Highest pressure on record, 30.79 inches on February 2, 1880; lowest pressure on record, 29.00 inches on November 28, 1892.

GEORGIA.

Mr. Park Morrill, Local Forecast Official at Atlanta, Georgia, reports the average temperature from a record of fourteen years and eight months (degrees F.): January 42.4; February 47.9; March 51.2; April 61.6; May 68.8; June 75.7; July 77.8; August 75.7; September 71.0; October 61.6; November 50.1; December 45.1; mean annual 60.7.

Precipitation in inches: January 6.27; February 5.15; March 6.16; April 3.66; May 3.59; June 4.43; July 4.64; August 4.56; September 4.10; October 2.41; November 4.00; December 4.68; annual precipitation 53.65.

The *mean relative humidity* is 69.3 per cent.

The *mean barometric pressure* for fourteen years is 28.918 corrected for temperature and instrumental error only.

Atlanta is situated 1050 feet above sea level on the most southerly foothill of the Appalachians, on the very crest of the ridge, so that the water falling on one side of the city flows to the Atlantic and on the other to the Gulf of Mexico. The natural drainage is excellent. To these facts is probably due its freedom from epidemic fevers and similar diseases.

TEXAS.

From Dr. I. M. Cline, of Galveston, Texas, the following data concerning the climate of Galveston is compiled, Texas being a State of such enormous dimensions that justice can hardly be done to its climatological position by considering merely one locality, but space prevents us from going more fully into the climatology of the different areas of the State. Compiled from 20 years' official records, the following data will represent more or less accurately the climate of Galveston :—*

Normal temperature by months (degrees F.): January 52.3; February 57.7; March 62.5; April 69.8; May 76.0; June 81.9; July 81.7; August 82.8; September 78.7; October 72.5; November 63.7; December 58.0, giving an annual temperature of 70.0.

The *normal precipitation* for the year is 52.48 inches, distributed as follows: January 3.98; February 2.98; March 3.17; April 3.37; May 4.30; June 4.96; July 2.98; August 5.51; September 7.07; October 4.96; November 4.61; December 4.59.

The *annual relative humidity* is 77 per cent., distributed as follows: January 79; February 83; March 79; April 78; May 75; June 74; July 74; August 74; September 74; October 74; November 78; December 82.

CALIFORNIA.

From the Annual Meteorological Review, a copy of which was forwarded by James A. Barwick, Director of the California Weather Service at Sacramento, the following meteorological data have been compiled.

California has the most extensive variety in temperature, as well as in rainfall. Certain portions give an annual temperature extremely high, especially in the desert regions, and others a

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* The relation existing between mortality and different conditions of temperature, has been thoroughly studied by Dr. Cline, and any one desiring to familiarize themselves with statistics on the subject will do well to refer to the Monthly Bulletins of the Texas Weather Service, which contain Dr. Cline's observations.

temperature proportionately low, this great range being dependent upon the altitude attained in the Sierra Nevada range of mountains.

The *average temperature* at Sacramento is about 60° F., with an annual precipitation of 20 inches; the relative humidity averages between 60 and 65 per cent. In the extremely dry areas, in the Desert and Death Valley regions of the State, the precipitation does not exceed three inches annually, while upon the north-western coast the rainfall reaches from 75 to 100 inches.*

NORTH CAROLINA.

From data supplied by Mr. von Herrmann of the U. S. Weather Bureau at Raleigh, North Carolina, the following data are compiled. Observations covering twenty-five years give a mean annual temperature of 60.1 F°, distributed as follows (degrees F.): January 41.2; February 45.2; March 49.2; April 58.9; May 68; June 76.1; July 79.8; August 76.9; September 71.8; October 60.8; November 50.4; December 43.2.

Precipitation in inches: January 3.38; February 3.67; March 4.22; April 3.15; May 4.18; June 4.08; July 4.82; August 6.00; September 3.52; October 3.36; November 2.02; December 3.27; mean annual 45.67.

The *relative humidity* by months: January 75; February 78; March 71; April 66; May 70; June 72; July 78; August 82; September 82; October 75; November 74; December 73.

NEBRASKA.

From Mr. G. A. Loveland, of the Nebraska Weather Service, we have received the following data:—

Temperature (degrees F.): January 18.4; February 23.6; March 34.5; April 48.9; May 58.7; June 69.7; July 74.5; August 72.4; September 63.4; October 50.4; November 34.7; December 26.1; mean annual 47.9.

Precipitation by months is: For January 0.71; February 0.80;

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* The student desiring to more thoroughly investigate the climatological features of the different portions of California is referred to the "Annual Meteorological Review of the State of California," compiled by James A. Barwick, which can be found in the Annual Report of the State Agricultural Society from 1882 to 1893.

March 1.12; April 2.52; May 3.80; June 4.05; July 3.62; August 2.90; September 2.00; October 1.89; November 0.69; December 0.74; mean annual 24.64 inches.

ILLINOIS.

From Mr. John Craig, Director of the Illinois Weather Service, we have received the following data:—

Mean temperature and annual rainfall for this State, compiled from data furnished by Illinois State Weather Service:—

Temperature (degrees F.): January 23.8; February 29.8; March 37.2; April 51.7; May 62.0; June 70.7; July 75.8; August 73.1; September 65.2; October 53.7; November 39.2; December 29.3; mean annual 51.

Precipitation in inches: January 2.32; February 3.07; March 2.75; April 3.33; May 4 44; June 4.84; July 3.18; August 3.23; September 2.93; October 3.03; November 3.30; December 2.46; mean annual 38.88.

NEVADA.

From Mr. Ford A. Carpenter, Observer, Weather Bureau, at Carson City, Nevada, we have received the following data:—

Temperature (degrees F.): January 30.7; February 33.3; March 40.8; April 47.7; May 56.9; June 64.2; July 70.8; August 69.2; September 62.4; October 47.7; November 37.2; December 34.7; mean annual 49.6.

Precipitation is about 12 inches annually, distributed as follows: January 1.89; February 1.58; March 1.58; April 1.08; May 0.71; June 0.44; July 0.20; August 0.15; September 0.28; October 0.37; November 1.40; December 2.37.

The *relative humidity* for the State averages about 52 per cent., lowest in the months of June, July, and August, and reaching its maximum during December and January.

From several years' averages, we find that during the year Carson City has a mean of 245 cloudless days and 60 days on which .01 of an inch or more precipitation fell.

WISCONSIN.

From W. L. Moore, Local Forecast Official, of Wisconsin Weather Service, the following climatologic data have been obtained:—

Temperature (in degrees F): January 19.7; February 23.5; March 30.0; April 42.4; May 52.9; June 62.8; July 69.0; August 68.0; September 60.9; October 49.3; November 35.6; December 25.7; mean annual temperature 45.

Precipitation in inches: January 2.23; February 1.90; March 2.51; April 2.79; May 3.57; June 4.10; July 3.23; August 2.93; September 2.78; October 2.49; November 2.06; December 2.01; mean annual about 32 inches. The maximum rainfall is reached in June and the minimum in February.

The average *relative humidity* is about 74.6 per cent., and the mean annual barometric pressure, uncorrected, is 29.26 inches.

Above data compiled from twenty-two years' observations.

IOWA.

From documents furnished by Dr. George M. Chappel, Local Forecast Official at Des Moines, Iowa, the following data have been compiled. By observations covering many years, it is found that the climatologic features as observed at Des Moines practically represent the mean for the State and are as follows:—

Temperature (degrees F.): January 17.5; February 23.5; March 33.9; April 50.1; May 60.2; June 69.7; July 74.3; August 71.8; September 63.0; October 52.2; November 36.8; December 26.0; mean annual 48.2.

Precipitation in inches 35.66, divided as follows: January 1.42; February 2.35; March 1.52; April 2.62; May 5.20; June 5.68; July 3.79; August 3.44; September 3.04; October 3.47; November 1.82; December 1.31.

The average *relative humidity* is 70.6, varying but little for the different months of the year.

Mean uncorrected barometric pressure 29.12 inches.

SOUTH CAROLINA.

Through the courtesy of Mr. J. H. Harmon, Director of the South Carolina Weather Service, we are indebted to Dr. W. W. Anderson, of the Statesburg Weather Service, for the following data, estimated from ten years' observations:—

Monthly *mean temperature* (degrees F.):—January 44.7; February 50.8; March 52.6; April 62.7; May 70.1; June 76.4;

July 78.1; August 76.6; September 72.4; October 62.9; November 53.6; December 47.8.

Precipitation in inches: January 3.68; February 3.06; March 3.91; April 2.02; May 3.62; June 3.62; July 4.83; August 4.48; September 3.48; October 2.78; November 1.87; December 2.83.

No statement as to mean relative humidity or barometric pressure could be obtained.

NORTH DAKOTA.

Mr. W. H. Fallon, Director of the State Weather Service at Bismarck, North Dakota, supplies the following data:—

Temperature (degrees F.): January 0.8 (below zero); February 5.6; March 21.3; April 40.0; May 53.1; June 63.6; July 68.6; August 64.9; September 54.6; October 42.0; November 26.0; December 10.2; mean annual 37.4.

Precipitation in inches: January 0.64; February 0.60; March 0.68; April 1.68; May 2.25; June 3.53; July 2.86; August 2.16; September 1.63; October 1.55; November 0.58; December 0.72; annual 18.90. The average summer temperature is 66 degrees, and the average winter temperature 5 degrees. The lowest recorded temperature from records of 17 years is 54 degrees below zero at Pembina; the highest temperature recorded in the State during a similar period is 107 degrees at Fort Buford.

Relative humidity: Average annual, 74 per cent. Northeast section 79; southeast 75; northwest 70; southwest 71. (Absolute humidity 100.) Mean winter relative humidity about 80; mean summer relative humidity about 70.

Average number of days each month on which .01 of an inch or more precipitation occurs, 9. From September to December, inclusive, the average is 6½ inches; from May to July, inclusive, the number is 11.

Average annual barometric pressure, reduced to sea-level, 30.02 inches. Northwest and southwest sections 30.01; northeast 30.03; southeast 30.02.

OKLAHOMA.

From Mr. J. I. Widmeyer, of the Oklahoma Weather Service, the following data have been received:—

Temperature (degrees F.): January 35; February 42; March 44; April 60; May 65; June 75; July 78; August 77; September 72; October 61; November 46; December 40; mean annual 58.

Precipitation in inches: January 1.70; February 1.33; March 3.10; April 2.82; May 8.91; June 3.60; July 4.92; August 2.53; September 3.36; October 2.50; November 1.09; December 4.00; mean annual 39.89 inches.

Oklahoma City has an altitude of 1239 feet with a relative humidity of 73 per cent. and a total rainfall of 39.89 inches, and as Mr. Widmeyer points out, the location between the 35th and 39th parallels of latitude places the region in an area not subject to the excessive cold of the North or to the extreme heat of the South.

These data are collected from records extending back to November 1, 1890.

ARKANSAS.

Reports covering a period of fourteen years, from Little Rock, Arkansas, afford the following averages, obtained from Mr. F. H. Clarke, Director of the Arkansas Weather Service:—

Mean temperature by months (degrees F.): January 40.8; February 46.7; March 52.2; April 63.5; May 70.0; June 77.7; July 81.0; August 79.0; September 73.0; October 63.7; November 51.2; December 45.3; average 62.0.

The precipitation by months (in inches): January 4.83; February 5.70; March 4.75; April 5.04; May 5.54; June 4.24; July 3.83; August 4.12; September 3.25; October 2.50; November 5.71; December 4.65; average annual 54.16 inches.

Relative humidity (per cent.): January 76; February 73; March 68; April 68; May 74; June 77; July 75; August 76; September 76; October 74; November 73; December 74; mean 74 per cent.

The climatic data of Little Rock gives a fair average for Arkansas, as it is situated nearly in the center of the State. In the southern counties the temperature is slightly higher, while in the northern counties, particularly on the elevated plateaus of the northwest, the temperature is much lower; thus Fayetteville, Washington County, gives the following seasonable temperature deduced from six years' record: Spring 57.2; summer 74.2; autumn 60.0; winter 37.6.

LOUISIANA.

From the office of the U. S. Weather Bureau at New Orleans, La., Captain Robt. E. Kerkam, Local Forecast Official and Director, the following resumé of the climatologic features of New Orleans, compiled from records of twenty years, have been obtained:—

Mean temperature (degrees F.): January 53.8; February 58.5; March 62.5; April 69.5; May 75.1; June 80.2; July 82.6; August 81.5; September 78.2; October 70.7; November 61.7; December 56.5; mean annual 69.2.

Maximum temperature (degrees F.): January 62; February 82; March 84; April 88; May 92; June 97; July 96; August 96; September 94; October 90; November 85; December 80.

Minimum temperature (degrees F.): January 15; February 25; March 30; April 38; May 54; June 58; July 68; August 63; September 56; October 40; November 30; December 20.

Precipitation in inches: January 5.40; February 4.30; March 5.68; April 5.38; May 5.32; June 6.77; July 6.42; August 6.20; September 4.93; October 3.42; November 4.46; December 4.74; annual 63.02.

Mean humidity (per cent.): January 74.2; February 71.8; March 71.3; April 71.4; May 71.7; June 74.2; July 74.4; August 75.1; September 74.3; October 72.0; November 72.9; December 74.6, with an annual humidity of 73.2.

Mean annual barometer 30.00 inches.

Prevailing winds: January, N.; February, S. E.; March, S. E.; April, S. E.; May, S. E.; June, S. E.; July, S. E.; August, S. E.; September, E.; October, N. E.; November, N.; December, N.

Average number of clear, partly cloudy, cloudy, and rainy days, respectively: January, 8, 12, 11, 10; February, 8, 11, 9, 9; March, 10, 10, 11, 9; April, 11, 11, 8, 10; May, 11, 14, 6, 10; June, 8, 16, 6, 14; July, 8, 17, 6, 16; August, 8, 17, 6, 14; September, 11, 13, 6, 11; October, 15, 11, 5, 7; November, 12, 9, 9, 9; December, 9, 12, 10, 11.

Average date of first frost of fall and winter: November 25.

TENNESSEE.

From data supplied by Mr. J. B. Marbury, Local Forecast

Official at Nashville, Tennessee, the following data have been compiled :—

Mean annual temperature is about 60° F., distributed as follows : January 34 ; February 45 ; March 51 ; April 62 ; May 73 ; June 77 ; July 78 ; August 79 ; September 68 ; October 58 ; November 41 ; December 36.

The *mean annual precipitation* is 60 inches, although of late years there has been a gradual decline in rainfall, not commonly rising to that height. The following figures give a proximate average for several years : January 3.73 ; February 7.89 ; March 3.94 ; April 9.10 ; May 4.79 ; June 3.79 ; July 4.84 ; August 4.39 ; September 2.19 ; October 5.24 ; November 3.07 ; December 4.93.

The *annual mean relative humidity* ranges about 70, with the highest in the winter and the lowest in the summer months.

The *mean barometric pressure* at Nashville is 29.48 inches.

UTAH.

Mr. Geo. N. Salisbury, of Salt Lake City, sends the following data compiled from nineteen years' observations :—

The average *temperature* for the above period (mean annual temperature) 51.8° F. By months : January 27.7 ; February 33 4 ; March 42.0 ; April 50.8 ; May 59.3 ; June 68.1 ; July 75.5 ; August 74.9 ; September 63.9 ; October 51.2 ; November 40.0 ; December 34.5. Highest temperature on record 102 F. Lowest temperature recorded 20 below zero. A below zero temperature is very rarely reached.

Average *relative humidity :* Mean annual 50 per cent. By months : January 65 ; February 63 ; March 54 ; April 50 ; May 46 ; June 40 ; July 36 ; August 37 ; September 38 ; October 38 ; November 56 ; December 66 per cent.

Average *barometric pressure* at this elevation (4345 feet) 25.64 inches.

At Salt Lake City the average annual precipitation, 1874 to 1890, inclusive, was 16.71 inches. By months as follows : January 1.52 ; February 1.38 ; March 1.92 ; April 2.36 ; May 1.78 ; June 0.75 ; July 0.51 ; August 0.81 ; September 0.83 ; October 1.70 ; November 1.43 ; December 1.66. The above averages have not materially changed since 1890. From middle of May to 1st of October is the dry season.

The figures answer pretty well for the valleys of Northern Utah. At Ogden the precipitation appears to be somewhat greater, two to four inches annually. This may be due to slight discrepancy in measurement.

NEW JERSEY.

From Mr. E. W. McGann, Director of the New Jersey Weather Service, we are informed "that the normal rainfall in New Jersey is 46.88 inches. The wet season or period of heavy rainfall is during the months of June, July, and August, and the dry season, September, October, and November. The average temperature by months in degrees Fahrenheit is: January 30.4; February 32.3; March 36.9; April 49.1; May 60.2; June 70.0; July 73.5; August 71.7; September 65.0; October 53.2; November 42.7; December 53.7, and the annual 51.6. No observations of the barometer and hygrometer are taken."

MARYLAND.

From Dr. C. P. Cronk we have received the following data, compiled from the reports of the United States Department of Agriculture, co-operating with the Maryland State Weather Service:—

The *mean temperature* of Maryland is 53 8° F., divided as follows: January 32.8; February 34.8; March 39.6; April 51.7; May 62.6; June 72.5; July 72.5; August 74.3; September 66.9; October 54.7; November 44.0; December 35.3.

Precipitation in inches 42.43, distributed as follows: January 3.31; February 3.07; March 3.92; April 3.75; May 4.21; June 3.72; July 4.11; August 3.77; September 3.67; October 2.75; November 3.22; December 2.69.

Relative humidity (Baltimore, which is slightly lower than the mean for the State) is 56.3 per cent. for the year; distributed as follows: January 70; February 65; March 64; April 61; May 65; June 68; July 68; August 70; September 74; October 68; November 70; December 68. Prevailing direction of wind at Baltimore, northwest from October to April, inclusive; southeast during May and June; southwest during June and July, and north during September.

Compiled from twenty-two years' records.

NEW MEXICO.

From Mr. H. B. Hersey, Observer, Weather Bureau, Santa Fe, New Mexico, the following data have been received:—

Temperature (degrees F.): January 27.4; February 33.8; March 40.7; April 47.6; May 55.9; June 64.8; July 70.0; August 67.6; September 61.0; October 50.9; November 38.6; December 32.4; mean annual 49.2.

Precipitation in inches: January 0.55; February 0.83; March 0.66; April 2.18; May 1.03; June 0.83; July 0.58; August 2.18; September 1.57; October 0.81; November 0.76; December 1.03, giving a total rainfall of 12.71.

Relative humidity (per cent.): January 60.8; February 57.0; March 48.3; April 42.7; May 39.4; June 36.0; July 46.4; August 49.2; September 50.4; October 45.6; November 50.9; December 59.2; mean annual less than 50.

This indicates an extremely dry climate with comparatively low summer temperature and reasonably high winter temperature. The above means, taken from ten years' observation, show the wet season to consist of the five months from May to September, inclusive.

NEW YORK.

From Mr. E. T. Turner, through the courtesy of Mr. E. A. Fuertes, Director of the Central Office of the Meteorologic Bureau in New York, we are indebted for the following data:—

The warmest section of New York is that adjacent to the Atlantic coast, the normals for which are (degrees F.): January 30.5; February 31.5; March 35.9; April 46.7; May 57.6; June 67.0; July 72.3; August 71.1; September 65.3; October 55.1; November 43.9; December 34.5; mean annual 50.8. The extreme northern section of the State is the coldest: January 15.9; February 17.3; March 26.5; April 40.4; May 55.5; June 64.2; July 68.2; August 65.9; September 58.4; October 45.7; November 32.2; December 22.2; mean annnal 42.8.

Mean for the State: January 21.5; February 22.8; March 29.1; April 42.2; May 55.6; June 64.9; July 69.2; August 67.3; September 60.3; October 48.3; November 36.2; December 26.3; mean annual 45.3.

Precipitation for January 2.64; February 2.44; March 2.75; April 2.71; May 3.35; June 3.70; July 3.78; August 3.31; September 3.22; October 3.52; November 3.11; December 2.82; mean annual 37.35 inches.

The season of maximum rainfall is the summer months (10.79); the minimum precipitation is during the months in winter (7.90 inches). The proximity of the southeastern portion of the State to the seashore gives the maximum amount of rainfall 44.70 inches, while along the Champlain Valley the minimum is reached, 29.89 inches.

The relative humidity, taken from a record of thirteen years at Albany, is 70 per cent.; in New York from sixteen years' record it is 70 per cent.; in Oswego for sixteen years, 71 per cent. Albany here represents the inland stations, New York the Atlantic Coast stations, and Oswego stations on the Great Lakes.

The barometric pressure, corrected for altitude and temperature, gives mean annual of 30.03 inches for the State.

AVERAGE DATES OF KILLING FROSTS.

STATION.	LAST IN SPRING.	FIRST IN AUTUMN.	LENGTH OF RECORD.
New York City (representing Atlantic Coast Line),	April 13th	November 5th	18 years.
Rochester (representing colder part of Great Lake Region),	May 5th	October 15th	18 "
Erie, Pa. (near N. Y. border), (rep. warmer part G. L. Region),	April 23d	October 30th	18 "
Cooperstown (colder part of Central Highlands),	—	September 27th	30 "

PENNSYLVANIA.*

H. L. Ball, Observer, Weather Bureau, Assistant Director Pennsylvania State Weather Service:—

In consequence of the singularly complicated surface of Pennsylvania, it is extremely difficult to give, in a condensed form,

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* Following "Blodgett's Climatology of Pennsylvania."

even an approximate distribution of heat and precipitation—the two most important meteorologic elements affecting human life and pursuits.

Reference to a topographic map shows, first, a large area south and east of the mountains, lying at a general level not greatly elevated, and with drainage toward the Atlantic. This great plain, 150 miles long and 40 miles broad, is traversed by ridges of more elevated land, rising to heights of 600, 800, and even 1000 feet above the level of the sea.

The Allegheny Mountains traverse the State a distance of 230 miles, and reach an elevation of 2000, and at many places 2500 or more feet. Among the labyrinth of mountains in this section may be found many elevated plateaus, in which lie embosomed a multitude of beautiful lakes, with surrounding scenery unsurpassed by any other part of the world.

The surface of Northwestern Pennsylvania is less rugged than the central part, but the land lies at a high elevation and is everywhere broken by deep ravines. West of the rough section in McKean, Venango, and Warren Counties extends the high plateau which breaks down sharply, 1000 or more feet, a few miles from Lake Erie, to the comparatively low lake level. In the southwest are also high table lands, lying nearly 2000 feet above the sea-level, and almost surrounded by the great rivers of that section.

Considering these topographic divisions in order, we at once see the great effect the character of the land surface has upon the climate. In the southeastern or seaboard district and in the Ohio Valley on the west, the summer heats are more than tropical, while in the elevated regions of the northeast and the high plateau in the northwest, the winters are often of great severity. There is a difference of from two to four degrees between the temperature of the deep valleys and the highlands. Blodgett in his "Climatology of Pennsylvania" gives an apparent rule applicable to the decrease in heat due to elevation; that rule being approximately one degree for every five hundred feet at low elevation, and one degree for every six hundred feet in the mountains and higher plateaus. We also clearly note the effect of topography upon precipitation distribution,—which will be treated of further on.

The normal temperature for the southeastern district of Pennsylvania is about 51.9° F. For the seasons we have: spring, 49.6° F.; summer, 72.7° F.; autumn, 53.7° F., and winter, 31.5° F.

The distribution of precipitation in this section is worthy of note and well illustrates the effect of topography. In the immediate vicinity of Philadelphia the average yearly precipitation is about 44 inches, while at West Chester and over a large belt extending northeastward to the Delaware the mean annual precipitation exceeds 48 inches. Beyond this belt and covering the lower Susquehanna Valley the mean lowers, until at Gettysburg an average of 39 inches is had.

Northeastern Pennsylvania is represented by records from five places, extending over a period from 8 to 28 years. These give a normal temperature of 45.6° F., with the seasons as follows: spring, 43.3°; summer, 66.8°; autumn, 47.7°, and winter, 24.9°. The annual precipitation is less than 40 inches in the extreme northeastern counties, and increases to 48 inches further southward.

Northern Central Pennsylvania is deeply cut with the great river valleys which modify the climate to a considerable degree. This is especially true in the Susquehanna Valley. Representative positions in this district give the following normals in degrees F.: yearly, 48.0°; spring, 45.7°; summer, 69.2°; autumn, 49.6°, and winter, 27.9°. The mean precipitation varies greatly, ranging from 40 inches at Williamsport to 50 inches in a large area embracing Clearfield, Cameron, and portions of Clinton, Elk, Forest, and Clarion Counties. Surrounding this area are belts in which the annual precipitation varies from 40 to 48 inches.

The hills and plateaus of Northwestern Pennsylvania are colder than the region bordering on Lake Erie, and about as cold as any of the eastern highlands. There is, however, no district with a mean temperature much below 44°. At Erie, owing to the influence of the lake, the mean temperature is 49°; the summer months being from 5° to 7° cooler, and the winter months correspondingly warmer than the interior. Selected stations in this district, including Erie, give the following normals in degrees F.: yearly, 47°; spring, 44°; summer, 68°; autumn, 49°; winter, 26.° From Meadville southward the climate is sensibly modified by the warmer western and southwestern sections, giving Meadville nearly the same mean temperature as has Erie, and from 3° to 4° warmer than the adjacent eastern highlands. The rainfall in this section is remarkably uneven, ranging from 40 to 50 inches in the interior highlands, and to 60 inches in the Erie belt. In the last named area is found the greatest yearly rainfall of any section of the State.

Western Pennsylvania's climate is similar to that found in the eastern counties upon the same latitude. Advancing southward, the mean temperature rises from 48° at Meadville to 51° at Beaver and Kittanning, and the increase is still more apparent in the river valleys tributary to the Ohio. Taking the records of New Castle, Butler, Pittsburgh, and Allegheny Arsenal (near Pittsburgh) we have a yearly mean of 51.5°, with the seasons as follows: spring, 50°; summer, 72°; autumn, 53°, and winter, 31°. The precipitation varies from 36 inches at New Castle and Butler to 44 inches at Meadville. In the Lower Ohio Valley the precipitation increases to nearly 44 inches yearly. Pittsburgh with 37.4° and Beaver with 43.9° inches, yearly, illustrate the increase.

The southwestern section enters to a considerable degree into the Ohio Valley, and is fairly represented by Canonsburg in Washington County. The heat of summer here is fully equal to the seaboard district in the same latitude, though the winters are colder. Combining the records of Canonsburg, Fayette Tannery, Somerset, Johnstown, and Bedford, we have the following means: yearly, 49°; spring, 48°; summer, 70°; autumn, 50°, and winter, 30°. These means are considerably lower than would be obtained by considering alone the records of Canonsburg and Fayette Tannery. Somerset, Johnstown, and Bedford are all in the highlands and their climate is more nearly like that of the mountains. The rainfall varies from 36 inches at Canonsburg to nearly 48 inches at Johnstown, while a small area in Fayette and Greene Counties has over 50 inches yearly.

Pennsylvania's climate is somewhat warmer than the mean of the temperate latitudes in the same position relatively. At Philadelphia and vicinity the winters are generally mild, with a light snowfall. The summers are warm and the heat is prolonged well into autumn. A similar climate exists in the Ohio Valley south of Pittsburgh. Again, the summers of McKean, Tioga, Potter, and other counties along the northern border are cool, and in excessively cool years frosts have occurred during every month. Along the lower Delaware frosts are not infrequently delayed until the middle of November. Temperatures as low as 25° below zero have been recorded in the colder districts, and Major Mordecai at Frankford Arsenal observed a temperature of 7° below zero in February, 1836. The lowest temperature recorded by the U. S. Weather Bureau during 20 years in Philadelphia was 5° below zero on January 10, 1875, and again on December 30, 1880. During the same period the highest temperature observed at Philadelphia was 101.5° on September 7, 1881.

"Altogether, Pennsylvania has a climate highly favored in many respects; usually dry, clear, elastic, and invigorating, it is the best of the temperate latitudes, and its very extremes are favorable to mental and physical activity."

NEW ENGLAND STATES.

The following data have been complied from records furnished by the New England Meteorological Society, through the courtesy of Edward C. Pickering, Director:—

The climate of the New England States consists of two distinct zones with marked climatologic difference. These are subdivided by differences due to latitude extending from the 41st parallel to the 47th (nearly), a gradual ascent showing marked difference between the two extremes. This area is again punctuated, as it were, by all interminglings of altitude from sea-level to Mount Washington in New Hampshire (6234 ft.) or Mount Katahdin in Maine (5000 ft.), and further variations are assured by wooded and cultivated areas intermingled with each other in varying proportions. The long seacoast makes the climate of that region, or belt, what is known as a marine climate. While the interior constitutes a varied land climate.

The zone of marine climate extends from St. John, N. B. (almost), to Greenwich, Connecticut, about one-fourth the entire eastern coast of the United States.

It is widest along the Maine coast by reason of the numerous inlets and bays, such as Frenchman's Bay, Penobscot Bay, and Casco Bay, although Massachusetts Bay, Cape Cod Bay, Buzzard's Bay, Narragansett Bay, and Long Island Sound make the entire coast one of the most salubrious summer climates in the world. The summer temperature is low, as is also the precipitation and relative humidity. The extreme northern limit of climatologic record for the coast is St. John, N. B., with a mean annual temperature of 40.6° F., distributed as follows in degrees F.: January 18.6; February 21; March 27.7; April 37.5; May 47; June 55.3; July 60.3; August 60.1; September 55; October 45.8; November 36.8; December 22.6. The annual precipitation is 53.78 inches.

Annual mean relative humidity is high, exceeding 80 per cent. The constancy of the climate is one of its most salient features, as rapid variations are not frequent and it does not make great rises or falls. Following down the coast belt, Bar Harbor comes next in importance, with a fairly constant normal temperature for each month: January 22; February 22.2; March 30.4; April 41.4; May 52.4; June 60.5; July 65.3; August 64.1; September 58.2; October 47.3; November 39.3; December 26.8. Mean relative humidity is not attainable from tables at hand, but adjacent points give a mean summer humidity of 74. At Boston the temperature shows a marked rise above the two points just given, the mean annual temperature being 48.2 F., distributed in months as follows (degrees F.): January 26.2; February 28; March 33.8; April 44.5; May 56.3; June 66; July 70.9; August 69; September 62.0; October 51.4; November 40.3; December 30.5. The precipitation, for same period, in inches was the following: January 4.21; February 3.57; March 4.28; April 3.60; May 3.58; June 3.29; July 3.57; August 4.09; September 3.16; October 4.12; November 4.78; December 3.42, giving a mean annual rainfall of 45.67 inches. The mean annual relative humidity is about 73 per cent.

New Haven possesses an even climate without marked changes, and represents the climatology of the northern shore of Long Island Sound and the southern coast of Rhode Island. Its mean annual temperature is 49.1° F., distributed in months as follows (degrees F.): January 26.7; February 28.3; March 35.8; April 46.8; May 57.3; June 67.0; July 71.7; August 70.2; September 62.6; October 51.4; November 40.5; December 30.8. The mean annual precipitation is 50.39 inches, distributed in the following proportions: January 4.21; February 4.23; March 4.80; April 3.86; May 3.54; June 3.26; July 5.37; August 5.50; September 3.91; October 4.14; November 3.96; December 3.61. The mean relative humidity for 1891 was 78, a slight excess over the normal.

For the interior of the New England States only a few fairly representative localities can be presented, and these with only brief data, as fuller observations are not on record.

Hanover is situated above midway of the area occupied by the two States, New Hampshire and Vermont, credited geographically as a part of New Hampshire. The mean annual temperature is 42° F., distributed through the year as follows (in degrees F.): January 16.0; February 18.8; March 28.2; April 40.8; May 54.5; June 64.2; July 66.7; August 66.7; September 56.7; October 45.0; November 33.6; December 20.1.

The annual precipitation is 32.99 inches, a marked lessening from Eastport, Me., for example, on the coast zone at almost the same latitude, but possessing an annual precipitation of a fraction less than 50 inches. The rainfall of Hanover is distributed for months as follows: January 2.70; February 2.05; March 2.48; April 1.96; May 3.09; June 3.4; July 3.16; August 3.11; September 3.00; October 2.86; November 2.75; December 2.39. Relative humidity 74 per cent.

Springfield, Mass., is situated in the southern part of the State west of the center, and presents the climate of Southwestern Massachusetts and Northern Connecticut. The mean annual temperature is 48.5° F., with the following monthly normals (in degrees F.): January 24.8; February 25.9; March 32.7; April 46.2; May 59.3; June 68.6; July 73.3; August 70.4; September 62.8; October 50.8; November 38.7; December 28.0. Precipitation is 46.14 inches, distributed as follows: January 3.44; February 3.51; March 3.70; April 3.28; May 4.17; June 3.87; July 4.6; August 4.53; September 3.60; October 4.22; November 3.83; December 3.53. Mean relative humidity slightly above 71 per cent.

Waterbury, Connecticut, presents the climate of the southern terminus of the interior climate and possesses almost the same climatologic features as does the northern part of Rhode

Island. The mean annual temperature is 48.6° F., with the following monthly means (in degrees F.): January 25.2; February 27.4; March 32.2; April 46.3; May 57.9; June 67.4; July 72.0; August 69.4; September 62.7; October 52.1; November 40.3; December 29.0. The annual precipitation is not given, but Middleton, an adjoining town, has 48.24 inches rainfall with the following monthly means: January 4.22; February 4.06; March 4.59; April 3.22; May 3.72; June 3.62; July 4.40; August 4.95; September 3.72; October 4.09; November 3.94; December 3.82. The mean annual relative humidity is not given for the interior stations, but is probably less than the coast, where it but slightly exceeds 75 per cent.

One of the benevolent features of the New England climate is the absence of rapid and extensive changes in temperature or humidity, and the dry areas of high altitude scattered over the interior. These features have made the region the haven of summer pleasure seekers, where the cool, dry mountain and seashore air act as the solace of summer rest. The mean annual precipitation for New England is 45.32 inches, distributed by seasons as follows: Spring 11.10 inches; summer 11.43 inches; autumn 11.44 inches; winter 11.35 inches. For the coast zone the mean rainfall is much higher than the interior, but as the increase occurs largely in the spring and autumn months, it does not alter the summer climate.

CHAPTER VIII.

SOIL.

The healthfulness of soil is dependent upon the character of the materials which enter into its composition, upon its porosity, and its permeability to air or water, or both. Soils which contain large quantities of water, or soils which are extremely compact, retaining the surface water, form one group, while soils which permit rapid percolation of surface water, that are porous to a high degree, and which yield their moisture rapidly on exposure to the sun, form another group.

In these there will be a great difference in the amount of moisture present. Water in the soil may exist as vapor or moisture, or beyond a certain depth the entire soil stratum will be saturated; in the former instance the soil porosity is occupied by both air and water, in the latter by water alone, one being known as the *stratum of saturation* and the other as the *stratum of humidity*.

In the solid clay or marlish soil the stratum of saturation will be less than five feet below the surface, while in the dryer sandy soils the saturated area will vary from five to ten or fifteen feet. The presence or absence of subsoil water will depend not only on the character of the soil but on its configuration. Thus, in mountainous, hilly, or undulating areas it will be found that the subsoil water lies nearest the surface at the lowest altitude and nearest the termination of the shed into whatever stream, sea, or water course drainage takes place. In pervious, moist soils near the ocean or tide water, the depth of the ground water is no doubt influenced by the tide as well as by the character of the soil.

Season materially influences the amount of ground moisture, both as aqueous vapor and subsoil water. The maximum for a given soil occurs after the wet season, and hence there are usually two periods in the temperate zones, one of the true maximum being in the spring, and for the remaining months another rise not equal to the spring and taking place early in the winter months or late in the fall. The minimum of moisture in the temperate zones usually occurs in the latter part of the summer season, and this makes, for the greater part of the inhabited globe, the termination of the dry season. As these observations are comparatively constant, in order to determine the *mean annual* soil humidity and subsoil saturation, observations must be made for the varying climatic conditions. These modifications of soil moisture also mark periods of greatest soil pollution. Thus in the autumn the recently deposited organic matter favors the growth and development of those poisons engendered by heat and moisture in the presence of decaying organic matter. Thus it is noticeable that for a given malarial locality the maximum of the poison is reached when the subsoil water rises in the autumn and is lowest during the midsummer months. The same applies to typhoid fever and other infectious diseases, largely propagated through pollution of soil and water. As cities are almost exclusively supplied by surface water, and as surface water must carry all forms of soil pollution, it is during the seasons of maximum soil pollution that the most dangers from water contamination arises. These are intensified, as pointed out under " Water," by the flushing rains, which carry *en masse* large quantities of infectious material which has been developing under most suitable climatic and telluric conditions.

Vegetation very materially modifies the amount of surface moisture, area of humidity, and thus indirectly, at times directly, the stratum of saturation; the amount of influence exerted will be dependent upon the character and density of the vegetation. Dense and more or less impermeable forests prevent the penetration of solar heat and the escape of surface moisture; properly selected trees have an extraordinary influence upon the removal of water from the soil. It is claimed that the eucalyptus abstracts from the soil large quantities of water, which it again yields by its leaves. There are probably more trees which act in a similar manner, though to a lesser degree; the silver maple, the silver poplar, and the willow afford fairly good examples of this group. As these trees grow most luxuriantly in moist soils, it will be found that, in the absence of other evidence, they may be taken as indications of a high degree of soil humidity or a superficial stratum of saturation ; notably is this the case in the sycamore and willow, as they are rarely found in the absence of moisture, while the poplar and the oak are more commonly associated with drier soils. Swamp grass, sickle grass, bulrush, and dock afford evidence of superficial subsoil water, while mullen, brier, and bluegrass are more constantly associated with upland or drier soils.

Another important factor in soil is the presence or absence of vegetable matter, more especially in the varying stages of decomposition; as examples of this we have the soils of thickly wooded districts, covered with an abundance of fallen foliage, which, decomposing, and at the same time retaining large quantities of moisture, affords an active agent in air and soil pollution. The decomposition of animal and vegetable compounds as going on in the soil is brought about by the action of several forms of microörganisms. Most of these are innocuous, belonging to the saprophytic group of bacteria. Their function in the soil consists in splitting up the organic compounds into carbon dioxid and water and possibly, under certain conditions, into various ethyl compounds, recognized as marsh gas. While, as has already been said, the majority of these organisms are saprophytes or non-pathogenic organisms, there are several pathogenic organisms which have their natural habitat in the soil, and others which incidentally may be therein stored. Among the pathogenic organisms almost constantly found in the soil, are tetanus, malignant edema, and many of the organisms associated with suppuration, and while the bacterial cause of malaria is still undecided, there remains no doubt that the etiological factor, whatever it may be, resides largely in soil, more particularly in that having a superficial subsoil saturation area and associated with a heat and decaying vegetation at a low altitude. The pathogenic organisms which are incidentally deposited in the soil, and which possess the faculty of residing there through a more or less indefinite period, depend largely upon the character of the soil and the temperature. Cholera, typhoid fever, erysipelas, and anthrax (including the so-called anthracoid diseases of animals) form the most important members of the group. There is every reason to believe that tuberculosis and many if not all contagious and infectious diseases may have a more or less temporary residence in the soil. In order that pathogenic or saprophytic microörganisms should have anything more than a temporary existence in soil, it is necessary that heat, moisture, and the essential elements for their nutrition should be present. These conditions are all found where there is decaying vegetable matter; superficial subsoil and a warm climate affording a temperature anywhere above 80°, preferably between 95 and 100° F, favor their development. From the gases present in soil is estimated the amount of vegetable or animal matter undergoing decomposition. In the former the excess of carbon dioxid will be apparent, and in the latter ammonia or its compounds. Tests for ammonia in the soil are not deemed reliable by reason of the ammoniacal salts normally present, but carbon dioxid in excess may be considered as conclusive evidence that decomposition of vegetable matter is going on. The amount of carbon dioxid which may be considered normal will vary with the season and the character of the soil. In the most healthful soils there will be between five and ten volumes per thousand in summer, and about one-fourth of the same in winter, while in made soils the volume may reach 107.5 per thousand (Fodor). These observations are made at depths of eight to ten feet.

Soil air, either dry or humid, to an enormous degree, may gain ingress to houses through the differences of temperature between the air in the house and the external air. The ingress usually occurs when the air outside is cool and the inside air heated. By atmospheric pressure the telluric vapor is forced into the house, through improperly cemented cellars, to take the place of the rising rarefied air within the habitation. If, therefore, the habitation be built upon made ground the soil air will carry into the house many of the noxious products of subsoil decomposition. These are to be guarded against by properly constructed walls with thoroughly cemented and ventilated wall spaces, as described under "Habitations."

Purification of Soils.

Subsoil Drainage. Where it may be necessary to remove superficial subsoil water, it can be accomplished best by methods of what are known as subsoil drainage, the efficiency of which will depend upon the method, character of the soil, and the amount of fall attainable. Sandy, permeable soils can be more readily drained than clay and denser soils, the latter requiring numerous drains, closely approximated with abundant fall and large percolation surface. The best subsoil drains are those made of broken limestone or unglazed crockery-ware tiles, with the best results obtained from a combination of the two, as shown by the accompanying illustration.

Subsoil drainage should never be connected with the sewage system, as in case of clogging of the latter the subsoil will receive the dammed up sewage matter, thus establishing a process of upward filtration and further pollution of the soil which it is desired to purify.

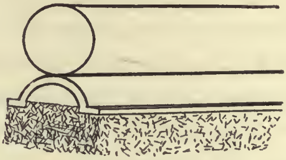
Where the excess of water is due to influx of water from an adjacent stream or water-course or to daily tidal rise, as along the seacoasts, dykes with trapped or gated outlets will be needed.

FIG. 82.

BROOKS DRAIN AND SUBSOIL PIPE.

The base sheet or bed is made of unglazed crockery ware and may be perforated. The drain proper is made of *terra cotta*.

FIG. 83.



DRAIN AND SUBSOIL PIPE LAID UPON CRUSHED STONES.

A combination at once cheap and most useful. The stone makes a very solid bed for the drain and favors the removal of surface water.

These are particularly useful in draining lowlands where tidal overflow occurs. The entire area to be drained is ditched and subsoil drains located with small areas between, the entire system conducted to the lowest point, and there discharged through a gated conduit, which is opened when the tide falls below its outlet, thus permitting the periodic outflow of accumulated surface or soil water, and closed when the tide rises. These gated outlets are now made automatic and require but little supervision. Where this plan cannot be resorted to the subsoil and surface water may be conducted to a suitable spot and there pumped out of the dyked area. This method is both expensive and unsatisfactory, as it is rare that sufficient storage or fall can be obtained.

If subsoil drainage be aided by cultivation better results will be obtained. The frequent stirring and handling of the soil will at first intensify the pollution by increasing the amount of organic matter brought to the surface; later this will nitrify and disappear, the sandy portion of the soil, rising to the surface, will favor evaporation and thus indirectly favor the desired result.

In urban localities, where houses are thick, these marshy areas are filled in and the resulting elevation is known as made soil. Properly the filling in should be first a layer of two or more feet of cobble-stone or good-sized rock, on top this may or may not receive a good layer of ashes, but lastly it is covered over by earth from superficial crust-layers on more elevated sites, preferably from the natural stratum the elevation of which it is desired to reach; if these directions are followed a desirable and healthful surface may be produced. Not infrequently the filling is done with street and house refuse, including discarded clothing, old shoes, bones, and other organic matter. This, supplied with an abundance of moisture, offers every opportunity for the development of all the dangers which soil pollution can induce. Not only is this process of making elevation unsanitary, but it is by far the most expensive. Loaded with organic matter, only partly exposed to the natural conditions for decay, the process is long, lasting for years, during which time all sewers, water-pipes, gas mains (city property), or dwellings (private property), if placed in or upon such soil, settle and become the source of interminable outlay. This is particularly worse if the bed upon which the elevation rests is boggy or made of sinking- or quick-sand. In such cases it may be necessary to drive piling through the uncertain bed and secure a resting place upon which the elevation can be constructed. These piles are driven closely together and a stone foundation formed upon the ends of the driven piles. In extremely uncertain bogs it may be necessary to concrete the bed before the stone is placed upon its surface, filling in the superimposed layers as already directed. These seem like expensive methods, but in the end they are the cheapest.*

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* In Philadelphia, Fourth Street, near Christian Street, runs over a bog, once occupied by a creek. The present elevation was secured by the ordinary filling in method now commonly pursued by cities. Within the last year it has been torn up no less than eight times for the repairs of sewers, broken water pipes, and gas mains, and the present year has been but little worse than the years which have preceded it. As an

Aside from suitable drainage, both surface and subsoil, the judicious cultivation of vegetation, planting of trees, not in excess, form important adjuncts. The value of the eucalyptus is here well established in climates where its growth is possible, and fortunately this growth is most luxuriant where most needed, namely, in damp and swampy malarial areas.

Diseases Due to Impurities in the Soil. Diseases propagated by the soil partake largely of the same characteristics as diseases spread by water; thus we have all the specific infectious diseases, microbic in point of origin, as possibly attributable to telluric pollution. It is possible, indeed probable, that soil containing decayed vegetable or animal matter may give rise to specific diseases from the lodgment of microörganisms, such as tetanus, malignant edema, typhoid fever, erysipelas, cholera, etc., in man, and in animals anthrax and anthracoid diseases. The almost indefinitely prolonged period which the soil may retain the specific properties of the organism renders these views more probable. Malaria partakes more or less intimately of many of the characteristics of the bacterial diseases, and affords us a type of the diseases due to specific organisms; reasoning backward from the knowledge which we already possess of similar diseases, it seems not improbable that the cause which gives rise to malaria, as engendered by heat and moisture in the presence of decayed vegetable matter, presents a type closely allied to, if not identical with, what may be considered the bacterial diseases. Viewed in the reverse, evidence is not wanting of the intimate relation between bacterial diseases and chronic paludism. Thus the bacteriologist would recommend for the sanitary improvement of soil containing decomposing organic matter in the presence of heat and moisture, that every effort be made to

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example of the reverse policy, a large sugar refinery in the same city has been constructed over a veritable bog. Piles were driven, the surface concreted, and a refinery constructed on this behind a specially constructed dyke or bulkhead to keep out tidewater during the process; as a result, there stands to-day a ten-story building of gigantic dimensions, loaded with the heaviest machinery, raw and refined product, without the slightest evidence of sinking and with subways and cellars in the best possible condition, although sixty thousand cubic feet of cellar is beneath the level of ordinary high tide. The city of New York affords innumerable examples of just such work. It is done by private individuals to prevent future outlay, not by corporation jobbers to secure continuous steals.

remove or at least reduce the moisture, improve the drainage, and alter the vegetation ; this has been found experimentally to have diminished the quantity of malaria and the intensity of the poison.

Another class of diseases to which soil seems to bear a certain definite relation are the diseases of the mucous membranes. The delicate and extensive circulation of the mucous membranes seems to be most sensitive in its reaction, and toxic elements present in the atmosphere or soil seem to be important factors in the propagation of diseases affecting the respiratory and alimentary mucous tracts. As long ago as nearly half a century, Bowditch, of Boston, called attention to the intimate association between moist soil and consumption, and while there have been no extensive observations bearing upon this subject, any evidence of the incorrectness of his conclusions has been entirely wanting. Dr. Bowditch's statements were formulated long before the bacterial origin of tuberculosis was established ; now one can see clearly reasons for believing that his observations would theoretically be well taken, even in the absence of statistical evidence to sustain them. Consumption is a disease which above all others has, as its principal cause, irritation of the mucous membranes, without which the disease rarely occurs, certainly not in either the pulmonary or intestinal form. This irritation affords a nidus, in which the active etiologic factor, the bacillus, gains ingress. In moist soil we have all the elements necessary for the propagation of this organism. The bacillus itself no doubt develops with avidity, and the disturbance of the mucous membranes favors the infection of the human organism.

With so clear an example as consumption, the influence of telluric impurities in the propagation of dysentery, diarrhea, and chronic catarrhs, nasal, bronchial, or intestinal, and other morbid processes of the same general character, can be attributed, either directly or indirectly, to perverted functional activity of the mucous tracts, engendered by polluted soil, air, and water, as observed in malarial districts and elsewhere, where the stratum of soil saturation is superficial and the stratum of humidity abnormally moist.

Soil Examination. In the examination of soil, the most practical thing for the sanitarian to determine is the power of the soil for absorbing and retaining moisture. This it is impossible to do from small samples sent to the laboratory, but must be done by making a critical examination of the soil *in situ*, taking into consideration the nature of the subsoil, the conformation of the land, the presence of large bodies of water, and the meteorologic conditions, etc. As soil varies considerably within small areas, a number of samples must be collected before one can with any certainty determine its quality. Samples may be obtained from any depth by means of borers. Borers consist essentially of pieces of iron tubing (boring rods) varying in diameter from one-half inch to two inches or more. At one end of the tubing is an opening, and from the back of the opening, and inclining forward, is a piece of steel. To the lower end of the tubing is attached a spiral bit, and at the other end a cross bar or means for connecting with a boring machine.

As the bit penetrates the earth, soil is gathered and forced by the steel into the hollow of the boring rod. A borer bearing the name of Frænkel is one that is often recommended.

Chemical Composition of Soil. The procedure outlined by Schulze is the best for determining the chemical constituents of soil. Pieces of rock and large stones are first removed from the samples, the earth is dried in the air and then placed, without crushing or pulverizing, in a glass funnel lined with strong filter paper. Pure distilled water is poured into the funnel until the soil is covered. If the first of the filtrate is turbid, return again to funnel. The process of extraction is continued until two or three times the weight of the soil is represented by the weight of the filtrate. The several filtrates are incorporated, and then divided into a larger and a smaller portion. A part of the washed soil is retained for further treatment. The larger portion of the filtrate is evaporated in a porcelain dish over a water bath to one-fourth its bulk. A small quantity of the concentrated solution is tested by the methods described under "Water" for organic matter and chlorin, and the remainder evaporated over a water bath to dryness; it is then ignited, that the organic matter may be thoroughly burnt off. The ash is tested for manganese by fusing upon platinum foil a small portion of the ash with two or three parts of sodium carbonate; if manganese be present sodium manganate is formed, which appears while hot a transparent green, but when cold a bluish green. What remains of the ash is dissolved in hydrochloric acid, and the appearance of any effervescent indicates carbonic acid. This is again evaporated to dryness, moistened with hydrochloric acid, water added, the mixture warmed, and filtered. The filtrate is tested for sulphuric acid, phosphoric acid, iron, magnesia, potassa, soda, and lithia. Carbon, clay, and silicic acid are, generally, the chief constituents of the residue. To detect the silicic acid, the residue is washed, boiled with caustic soda, filtered, saturated with hydrochloric acid, evaporated to dryness, and water added, when all the constituents except the silicic acid will be dissolved.

The smaller portion of the original aqueous solution is now tested for ammonia, nitric and nitrous acid.

The water-washed soil, which represents about 90 per cent. of the whole, is now tested as follows: 50 grams of the soil, to which a small quantity of 40 per cent. hydrochloric acid and 100 c.c. of water are added, are heated over a water bath for several hours and then filtered. The filtrate, containing those constituents which are soluble in an acid medium, is tested for iron, manganese, copper, alumina, lime, fluorin, magnesia, lithia, soda, potassa, and carbonic, silicic, phosphoric, sulphuric, and arsenic acids.

The presence of peaty acids is determined thus: A sample of soil is dried and, to separate straw, roots, and stones, is sifted. The soil which passes through the sieve is digested with sodium carbonate at a temperature of from 80° F. to 90° F. for several hours. It is then filtered and the filtrate acidified with hydrochloric acid, when, if the peaty acids be present, they will appear as brown flakes. Separate the flakes, place them in a weighed filter, and wash until the water shows color, then dry and weigh. Ignite the dry mass, deduct the weight of ash, and what remains represents "acids of humus," or ulmic, humic, and geic acids.

Water in Soil. The water in the soil may be considered under two heads: first, that held by the ground-air and known as moisture; second, that forming a large sheet immediately above the impermeable strata and known as ground water. The amount of moisture depends mainly upon the temperature, the character of the subsoil, the rainfall, the amount of water in the underlying ground. Take a known weight of the soil and dry it at a temperature of 220° F. When perfectly dry, again weigh it, and the loss in weight is equivalent to the amount of moisture that was present. Many samples from different areas of the district under investigation and also from varying depths must be examined before anywhere near an accurate estimation of the moisture of the soil can be obtained. If the examination cannot be conducted upon, or very near, the ground under investigation, the soil should be collected in glass flasks and the flasks stopped with soft rubber stoppers and hermetically sealed with wax for transportation, in order to prevent drying *en route.*

The height of the level of the ground water, or area of saturation, varies greatly with the season, but can readily be determined by boring holes in various parts of the ground and noting the height to which the water rises.

A clue to the amount of moisture in the ground of a district may be had from the character of the vegetation growing thereon, and from a practical point of view affords a better criterion as to the agricultural value of a soil than any conclusion that can be deduced from laboratory tests for determining the amount of moisture.

The character of the vegetation growing upon wet and dry lands has been adduced in the foregoing portion of this chapter.

As soils differ widely in their constituents, it is but natural that they differ in the amount of water which they are capable of taking up and retaining; thus, for example, loose sand may retain about two gallons per cubic foot, the ordinary sandstone one gallon per cubic foot, while clay sand absorbs 20 per cent., chalk 13 to 17 per cent., and humus from 40 to 60 per cent.

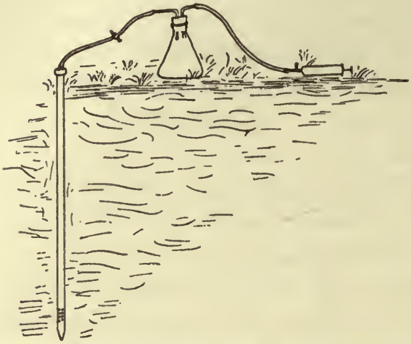
The *hygrometric* properties of a soil may be determined by rendering the soil absolutely dry, and then placing it in a bell jar over water. After several hours again weigh, and the excess in weight indicates the amount of water that it has absorbed.

Heat in Soil. Schubler has made a number of extended observations regarding the heat-absorbing and retaining properties of the soil, and he classifies them in the following order: 1st, sand; 2d, light clay; 3d, gypsum; 4th, heavy clay; 5th, clayey earth; 6th pure clay; 7th, fine chalk; 8th, humus.

The temperature of the soil, undoubtedly, greatly influences the rapidity with which organic matter is decomposed, the amount of moisture in the soil, the character of the ground air, and the life of microörganisms.

Ground Air. Fig. 84 illustrates Hesse's apparatus for collecting ground air. To collect the air, clamp the rubber tubing connecting the steel tube with the receiver, exhaust the containing flask, and then remove the clamp. The first sample collected should be rejected and a second sample collected. When the receiver is filled, secure the air by clamping the rubber tubing attached to the glass tubes of the receiver. The ground air is analyzed in the same manner as atmospheric air. Especial care should be taken in estimating the amount of carbon dioxid and organic matter, as they are the most important constituents.

Fig. 84.



Hesse's Apparatus for Collecting Ground Air.

When large volumes of ground air have escaped into the basement of a dwelling, it may be detected by estimating the amount of carbon dioxid, as any considerable excess of this gas not otherwise to be accounted for is to be attributed to this source.

The period of the maximum amount of carbon dioxid in ground air is between the months of July and November.

Biologic Examination of Soil. The bacteriologic analysis of soil cannot be underestimated, and the conlcusion that may be deduced from a carefully conducted study of the bacteria is from a sanitary standpoint of vastly more importance than a chemical analysis. The microörganisms living in the surface soil are, almost without exception, saprophytes. As the pathogenic organisms are destroyed by the saprophytes, they are found generally in the lower strata, where the saprophytes do not seem to penetrate. The length of time pathogenic organisms can remain in the soil without losing their vitality has not been determined, and, as Pasteur has cultivated from the soil the bacillus anthracis thirteen years after the body of an animal which died of charbon had been buried, it would seem impossible to fix a time limit. The most important of the pathogenic organisms to be found in the soil are those of tetanus, malignant edema, typhoid fever, cholera, tuberculosis, diphtheria, anthrax, and anthracoid diseases.

The part played by earthworms in regard to pathogenic organisms is interesting. It seems worms ingest the organisms in the lower strata and carry them to the surface, as pathogenic organisms have been detected in worms and in the surface soil, where their presence could only be accounted for on the hypothesis that the worms had carried them from the lower strata to the surface ground and there deposited them.

The various methods detailed under the "Examination of Water" are the ones principally used in making a biologic analysis of soil.

The soil is collected in sterile test-tubes or flasks having cotton plugs. For collecting dirt at some depth, Muencke, of Berlin, manufactures an apparatus especially devised for the purpose. Soil must be investigated immediately or we have, as in water, a rapid multiplication of the organisms. Koch in his first investigation of soil adopted a method which, though crude, was exceedingly simple, and, without effecting isolation of the bacteria, one could obtain a fair knowledge of the nature of the organisms in the sample. The dirt is collected in an ordinary sterile tube or flask. To inoculate the plate, remove the cotton plug and close the mouth of the tube by fastening over it a piece of filter paper; puncture in several places with a flamed pin and sprinkle the dirt lightly over the surface of a gelatin plate. Fraenkel advises that the dirt be placed in a tube of liquefied agar-agar or gelatin and agitated thoroughly, that the bacteria may be equally dispersed through the media. The same writer also prefers to measure the sample rather than weigh it, and he employed for the purpose a spoon, the bowl of which has sharp edges and holds about $\frac{1}{50}$ c.c. Samples of dirt may be placed in sterile water or bouillon and the latter treated as described under "Water."

CHAPTER IX.

HABITATIONS.*

Selecting the Ground or Site. This should be made with great discrimination and due regard to its suitability, from the standpoint of health. The highest considerations in selecting a site are those controlled by judgment and common sense, to wit: *Dry soil*, *warmth*, *light*, *air*, and *environment*. The latter creates the law of all that controls hygienic values, while warmth and dryness are synonymous; therefore, avoid the presence of all objectionable marshes or undrained lands in the immediate vicinity of the proposed site.

Dry Soil. Upon the dryness of the site depends absolutely the facility afforded for rain to pass off or through the soil. A gravelly soil of good depth and on a slope is the best site, since it affords natural drainage, and by reason of its depth the subsoil water is not likely to be superficial. Do not, however, be led away by the error that because the surface is of sand or gravel this is sufficient. There may be near the surface a stratum of clay or impervious stone, and this being impervious the upper crust will of necessity retain the water which should otherwise drain through and render it dry. Such a site is unfavorable, although much might be done to improve it by making subsoil drainage. (See " Purification of Soils.") Chalk soil is dry and healthy, as is also sandstone, provided (for the reason given above) it is of considerable depth and without a substratum of impermeable clay. Rock affords easy facility for drainage and is healthy, but here an obstacle presents itself, since the question of obtaining water in suburban and country residences is one of pressing importance. Clay, marl, peat lands, and made soil should be shunned

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* In the preparation of this chapter Mr. W. P. Lockington, architect, has written and supervised all that portion of the text which had practical bearing upon materials and construction, and all problems bearing upon heating, lighting, ventilation, and plumbing have been submitted for his approval. Illustrations by Mr. Lockington are acknowledged in the list of illustrations.

as dangerous and unhealthy, since the former is always damp, and favors the development of rheumatism, neuralgia, and pulmonary diseases; while the made lands, on account of the organic matter contained, increases year by year in its stage of putrefaction, until the air becomes impure, and affords an opportunity for the breaking out of zymotic or infectious diseases. Diphtheria and allied diseases are favored by these agents, and especially so during the fall of the year, owing to the presence of decaying vegetation; the latter also affords an ample nidus for the lodgment of malaria.

The *power of absorbing heat* differs in different soils, according to Schubler, who has estimated it as follows, assuming 100 as the standard :—[*]

Sand, with some lime,	100.0
Pure sand,	95.6
Light clay,	76.9
Gypsum,	72.2
Heavy clay,	71.1
Clayey earth,	66.4
Pure clay,	66.7
Fine chalk,	61.8
Humus,	49.0

These are the essential elements of a proof, and it therefore follows that the preference should be given as directed, paying attention to and encouraging the question of natural drainage, bearing in mind also that your house should not be too closely surrounded by trees, while the absence of vegetation is equally objectionable.

The question of site is often decided without the advice of the sanitarian or architect and its objectionable features are then to be overcome by (1) improving the environment and physical objectionableness and (2) by creating the best barriers in the materials and construction of the habitation. Deficient vegetation is to be overcome by favoring its growth, and excess or overproduction by removal or pruning. Superficial subsoil moisture should be removed by drainage, both surface and subsoil, and extra precautions taken against damp walls or cellars.

Objectionable and unsanitary industrial pursuits in the immediate vicinity are best overcome by municipal processes.

In selecting a site, the facilities for procuring good water and fuel are important.

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[*] See report by Dr. Bullard, published in 1889 as a supplement to the Report for 1887 of the Medical Officer of the Local Government Board.

Materials for Construction. Next to the selection of the site are to be considered the materials to be used in the construction; *wood*, *brick*, *stone*, *marble*, *granite*, *iron*, *steel*, and, of late, *aluminium*; *glass*, *slate*, *cement*, *asphaltum*, *concrete*, *lead*, *copper*, and other metals having special uses.

Wood. Frame and other forms of wooden buildings are rapidly becoming obsolete, due in part to their inflammability, to their want of resistance to the elements and to natural wear from use. The advantage of cheapness is no longer well taken, and when considered in respect to time appears adversely. Old wooden buildings are but forms of decaying vegetable matter, in the large majority of cases, and offer the best lodging for all forms of vermin and infectious parasites. Where wood is to be used in connection with other materials, the hard woods, such as walnut, cherry, mahogany, maple, ash, and oak offer distinct advantages over poplar, pine, and softer woods, except in the most protected situations, where the cheapness of the latter outweighs other considerations.

Bricks are strong, durable in all cases, and can be made to lend a picturesque individuality as well as stone. In making a selection for outer work, facing or ornamental dressing or trimming, choose a hard stock brick of good, uniform color and quality—naturally, they will be found to be more expensive—but for backing purposes, common red brick may be used. Bricks ordinarily are of a uniform size, 8½ inches in length by 4½ inches in width and 2½ inches in thickness, varying sometimes half an inch in length. They should be laid wet in dry weather, although this is not always done, and when laid in damp or freezing weather the brick should be laid thoroughly dry. Nothing can resist fire better than good, sound brick made from thoroughly tempered clay, and such bricks when thoroughly and well bedded will resist a pressure of 6000 to 8000 pounds to the square inch. Solid bricks should have been proved by standing in a kiln four or five days and subjected to a heat from 2000° F. to 2500° F., which affords convincing proof of their strength and durability. Preparations are made and sold by practical brick makers which prevent the white efflorescence seen so often upon house fronts after a severe frost. A good solution for the cleansing or restoring of old brick and giving to them their natural color can be made by adding one gill of muriatic acid to two gallons of water and applying same with a sponge or brush.

Stone, provided it be of the proper quality, has many advantages over some other building materials. Its durability is largely dependent upon the climate to which it is exposed, and hence definite rules cannot be formulated. The Northern and Eastern States, with an annual precipitation of thirty-eight to fifty inches and wide variations of temperature, are hard and severe tests. Whereas, our Southern and Western States, having a temperature more uniform, suffer less, and many a porous stone used in these latter named States which stands without injury for a century, would, in our Northern States, be found undergoing disintegration in a quarter of the time.

The precautions, therefore, which should be observed in the selection of building stone are these: In the regions where glacial action once prevailed and where the mass of rotten or decomposed rock has been entirely removed, if the surface of the rocks as displayed in the outcrop presents a fresh and undecomposed appearance, this may be asserted as a strong argument in its favor, although it cannot be accepted as conclusive. All beds or quarries, when opened, should be left exposed to the strong tests of light and weather for at least one year. At the expiration of one year the presence of any readily oxidizable mineral will have asserted itself, and the extent of induration or disintegration, as the case may be, will furnish a clue to its future behavior. A good building stone, whatever its kind, should possess a moderately fine and even texture, with the grain well compacted and set; when struck a sharp blow with a hammer, it will give a clear, ringing sound, and will show a clean, fresh fracture, without exposing a series of veins of mica strata to the sight.*

The porosity of any stone is usually characteristically shown by its manner of drying after rain. Some stones absorb a large quantity of water and will remain damp for a long period, while

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*See report of experiments on the transverse strength and elasticity of building stone, by Mr. T. H. Johnson: "The resonance of each piece tested was proportioned to the modulus of elasticity as found by the test."—*Report State Geologist of Indiana, from paper by G. P. Merrill, Curator Nat. Museum, Wash.*

others will dry quickly, and in this respect granite affords one of the best resisting stones. Since it is non-absorbent, it is always dry and self cleaning. Of sandstone, it may be said that the grains of which it is composed should be so closely compacted that the proportion of cementing matter need be very small. The various life estimates of stone may here be given. By the term life we would signify the number of years a stone will stand without discoloration or disintegration.

	Life in years.
Coarse brown sandstone,	5–50
Laminated fine sandstone,	20–50
Compact fine sandstone,	100–200
Limestone—coarse fossilliferous,	20–40
Limestone, fine colitic (French),	30–40
Marble dolomite (coarse),	40
Marble dolomite (fine),	60–80
Marble (fine),	50–200
Bluestone (sandstone),	probably centuries
Nova Scotia sandstone,	50–200
Ohio sandstone (best silicious varieties),	100 yrs. to many centuries
Granite,	50–200
Gneiss,	50 yrs. to many centuries

Ohio serves us with many good qualities, as also does Iowa, from pure limestone to magnesium limestone and dolomite. Connecticut brownstone also furnishes an example of weather-resisting stone, and Georgia good examples of veined marble. Pure limestone may be said to be as weather resisting as one that contains the necessary magnesium to constitute a true dolomite. Prof. Hall considers the magnesium limestone less durable than the pure limestone. The presence of coarse veins of mica, talc, and other materials materially lessens the durability of stone.

In adopting stone for large buildings or institutions, it must not be supposed that it is utterly impervious to the ravages of fire, although it may be accepted that limestone has a resisting force greater than that of sandstone, and granite better than either. Sandstone, coming in contact with severe heat, will crack, scale, and break in a short time, while limestone will, after exposure to fire for twelve hours, be found sometimes to be only superficially calcined.*

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*Shown in the late fire of the *Times* Annex and Central Theatre, Eighth and Sansom Streets, Philadelphia.

Iron and *steel* are used largely in connection with *marble* and *granite* or *glass* in the construction of fireproof buildings upon a large scale. Their advantages are manifest, but their general use is not promising for the present. In conjunction with tile or brick in the interior and granite stone or glass on the exterior, they leave but little to be desired. Their resistance to all noxious agents renders any praise from a sanitary point unneeded.

Glass Building Blocks. A problem, so often the bane of all architects' lives, how to give more light, or secure the ingress of light in dark corners, has been solved by the introduction of the glass brick or building block, formed in a flask shape, eight inches in length, the tube being 2¼ inches in depth and six inches in width, with an air chamber in center. The entire form is nicely moulded with an apex center, and along the ridges or moulded lines the glass is of sufficient thickness to stand a pressure of 150 to 200 pounds to the square inch.

This ingenious invention came from Switzerland, and was shown at the late Paris Exposition. It amply proves by its strength and simplicity the utter fallacy of our any longer suffering from the ill effects so often found in hotels and other institutions, of having dark corners, closets, or landings.

All the lines are so moulded as to allow of its being set top and bottom with ordinary cement, while the ends are secured by means of caoutchouc or rubber cement, thus doing away with framing lines. Taking an ordinary partitioned wall between two rooms, instead of using brick or studding, it need only be framed on the four sides and the bricks set in one deep, as that will then give a depth from apex to apex of nearly five inches. In remodeling old buildings, it will prove of the utmost value, as it can be used for outside or inside walls, and the utmost safety is assured for a space of twenty-one to twenty-four feet in length and twelve to fourteen feet in height.

Baron Rothschild was among the first to test the practicability of glass blocks in his large conservatory, the entire span or arched roof being formed of these bricks. While the light rendered for all ordinary purposes is almost equal to that of ordinary glass, it does not admit of anything being seen from the opposite side.

The ordinary bricks bear the greenish tint of common glass and are made in half and quarter sections. For all ornamental purposes colored glasses can be used, and for bath rooms the plain white may be used with admirable effect, as this latter bears a striking resemblance to porcelain.

Cement. A new process has been discovered and communicated to the French Academy of Sciences which will prove an excellent innovation on the old method of hardening plaster-of-Paris or cement so that it may be rendered durable and suitable for flooring purposes. The plaster is mixed with its weight of fine, freshly slacked lime and as little water as possible. After it is thoroughly dry, it is treated with a saturated solution of either zinc or iron sulphate; with the first, the hardened plaster remains white, while the second, by gradual oxidation, yields the color of iron rust, which gives it a fine imitation of mahogany under the application of linseed oil. This will prove very durable and at the same time economical, and a splendid substitute for inlaid and damp-proof floorings.

Concrete is a mixture of lime, cement, and gravel from which the fine sand has been eliminated; stone crushed into fine fragments, broken pottery, slag, rough stone, silicious rock and debris of coarse fossiliferous limestone, and glass; gravel, on account of its less adhesive properties, might be ignored. Concrete will in the future be an active agent; its use at present is limited, being used without the proper acknowledgment of its durability and strength, but here and there used for foundations, floors, and walls. The time, however, will come when concrete will be used exclusively and houses constructed of this material throughout. To apportion to it a good binding property, it should be, *pro rata*, made with good cement.

Protection of Walls during Building. Without regard to stress of weather, operations on walls are often commenced in the fall or spring of the year, and although the ground may be staked out during a period of fine weather, the foundation walls are commenced right upon a series of heavy rains and frosts, with the natural results following—sinking of the ground and a frost-pierced foundation wall, which will cause a loosening of the joints and a bulging of the upper walls. Specifications of architects usually require that all walls shall be properly covered during the progress of the work, and any failure to do so will be the architect's authority for having them repaired at the builder's expense and at the architect's discretion. All walls have to be, or should be, shown upon the drawings, and the specifications demand good, sound, local stone, set in naturally, or as it lies in the quarry bed.

Foundations. Except where the foundations are of rock or other solid material, a foundation of good concrete should be laid as a base for the wall footings. An avoidance of this precaution may render the building liable to subsidence, and thereby produce cracked walls. The depth of concrete for this purpose can only be regulated in accordance with the weight of the wall which has to be supported; in no case, however, should it be less than eighteen inches, and in width extend at least six inches beyond the footings. The height of the footings should correspond to at least two-thirds the thickness of the wall above, and project to a distance of one-half the thickness of the wall. This precaution is taken to prevent the stone shaling and peeling from atmospheric conditions. (This applies, of course, to parts exposed to stress of weather, and not foundation.) The stone should be laid with the joints horizontal, but not crossed, and should be also of sizes oblong, and set to bed, or as the stone rests in its natural bed in the quarry.* The stone should be thoroughly bonded in good mortar, made of well-burnt lime, and clean, sharp bar sand, thoroughly screened and mixed.

Foundation walls for all dwellings of not more than twenty feet frontage and twenty-five feet high should not be less than sixteen inches thick, and four inches should be added for every twelve feet additional height. Should the front be of greater height than twenty feet, the foundation walls should then be twenty-two inches in width.

Continental and English authorities regulate the height of their buildings by the width of the streets upon which they front; *i. e.*, if the street is fifty feet wide, fifty to eighty feet is the greatest height that may be legally attained, except in very special cases, such as church spires and chimneys.

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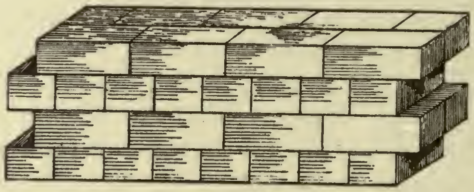
* In order to see what a disregard of this precaution may result in, see the First Baptist Church, northwest corner of Broad and Arch streets. There the stone is in a state of disintegration, or shaling.

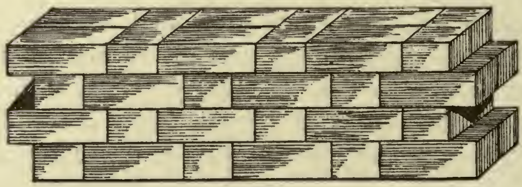
Walls. Above the height of one hundred feet the thickness should be determined by the architect and the building inspectors, after due consideration of the purpose for which the building is constructed. Where the length of the wall is not more than forty feet and the height forty-five feet, the first story should be seventeen inches thick and the remainder thirteen. And no party-wall built over the line should be less than thirteen inches thick, and should extend ten inches above the roof. No chimney should be corbelled out more than eight inches from the wall, nor should it be supported other than by stone, and where there is a party-alley the party-wall should be started upon an iron channel beam, supported by iron cross beams. No timber should be used for any wall where stone, brick, or iron is commonly used, except lintels.*

Fig. 85.



English or Block Bond.

Fig. 86.



Flemish Bond.

In the construction of brick walls, it is necessary to so inter-

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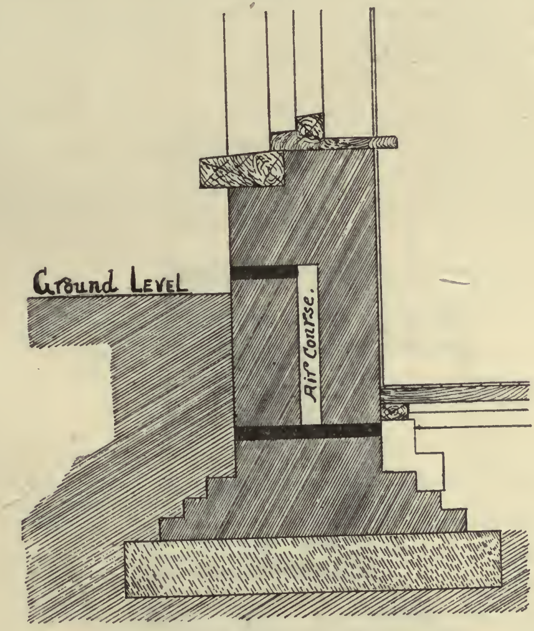
* No floor beams should be supported wholly upon any wooden partition. It has been and is the common practice for architects to specify and plan for wooden studding in ordinary residences as partition walls. An innovation was introduced, however, by one of our architects, who specified in the place of ordinary partition wall with studding a four-inch wall of brick, which is far better, but a building inspector, in his dense ignorance, failed to see the wisdom of it.

lace the bricks that they will tie the walls together in all directions. At the present day, it is usual to increase the strength of walls by the introduction of bond timbers and hoop-iron bonds. This applies only to larger buildings, and is not essential in ordinary dwellings.

The two methods of bonding in ordinary use are the English and Flemish bonds. In the former the courses of brick are laid alternately lengthwise and endwise, to which the term of header and stretcher is applied. The Flemish bond signifies that the bricks are laid with "headers" and "stretches" alternating in every course. Preference may be given to the former English bond on account of its superior strength and the facility it affords for tying.

Fig. 87.

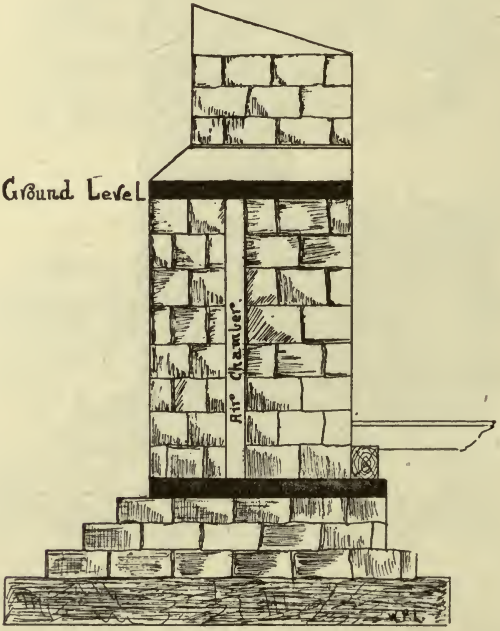


Damp-proof Course with Ventilated Air Chamber.

Damp-proof Course, or Air Course. Every precaution should be taken to protect the house from dampness, therefore a barrier should be imposed which will prevent the moisture being readily absorbed by the wall from the soil in contact with it, which will, by capillary attraction, rise even to the upper floors and rooms, rendering the house damp, unhealthy, and also causing the paper to fall from the walls. Inconvenience, useless expense, accompanied by sickness, is the inevitable result. This is an evil which cannot be remedied after the house is built.

A dry wall may be obtained by placing a damp-proof course or air chamber in the wall a little above the ground level. Bricks perforated longitudinally are so set as to allow a current of air to pass freely under the flooring; where the house is built with a basement kitchen and chambers, it is necessary to construct an area around the house, the bottom of which is below the basement floor, so as to admit of a damp-proof course being inserted between the floor and the bottom of the area in the manner described. This, however, is expensive and not always practicable. Slate, though often used, is liable to break, therefore it is better to use asphalt or a layer of cement.

Fig. 88.



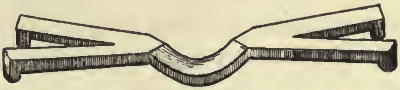
Damp-proof Course.
Containing a slate or asphalted stratum clear across the wall beneath the cellar and above the ground level. The air chamber must be well ventilated at many points.

Another plan is often substituted, but this does not answer so well for the purpose. The method for this is to build that portion of the wall which is above the ground hollow and insert two damp-proof courses, the one extending across the whole width of the wall, below the basement floor, and the other across the outer section of the hollow wall a little above the ground level. In either case, however, it is necessary to provide drainage from the bottom of the area or cavity; ample openings must be provided for uninterrupted ventilation.

Another method in use is to place in the cavity slate held in position by a bonding tie of a non-absorbent material. Stoneware and iron ties are to be recommended, since they are not affected by moisture. The ties, if of iron, should receive a coat of tar and sand.

It is found that masonry may be rendered impervious to water, especially in positions exposed to direct contact with that element, by the application of coal tar. The latter is employed in a boiling state in one or more layers, or it may be made to flame up before being used, the first being suitable for surfaces exposed to the air, while the second is appropriate in the case of parts intended to be covered up. This method of treating foundations is declared to be of special utility in all public buildings, particularly those designed for the preservation of works of art, preventing, as it does, exudations of water, charged with lime salts, from the mortar.

Fig. 89.



Iron Bonding Tie.

All necessary openings should be left for setting of soil pipes and arched over where they pierce the walls and the earth rammed solidly at the back.

Roof and Roofing. A good roof is necessary in order to maintain dry walls. It must have a good pitch, and be sufficiently well put together to stand all stress of weather, and be, in its relation with the other parts of the house, a question of little or no anxiety to yourself. If a so-called flat roof be needed, then it should slope toward the gutter channels, with a fall of not less than ⅝ of an inch to the foot, sufficient to cause the rapid flow of rain-water. When a pitched roof of slate is required, there should be an inclination of from 26 to 40 degrees.

Materials: Roofs may be covered with *tarred felt*, *tin*, *slate*, *tile*, *shingles*, *lead*, *copper*, *cement*, etc.

Tin may be conceded to be the cheapest, if we deal with the question of a cheap roof, and one calculated to last, if properly painted; two good coats of paint must be applied at least every fourth year. The tin plates should receive one coat of paint on the under side and three coats on the upper side, composed of the best linseed oil and mineral paint. The edges should be well lapped over in the laying, and the flashing for the gables, against the chimneys, or in the valleys, be well attached to preclude the possibilities of rain or damp forcing its way beneath. *Flashings* are sheets or strips of metal covering the joints of the tin or slate, and fastened to the wall or chimney brick-work.

Slate is used very extensively, and is to be recommended as a good roof. The characteristic of good slate is its ability to resist the absorption of water; an approximate test may be made by soaking the slate in water. It is also common to take it and breathe upon the slate, and if then it emits a clayey odor or "dead flesh," as it is termed, and shows a moisture mark, it may be condemned. A fine texture, an absence of heavy veins or streaks, and a clear, ringing sound when struck, may be accepted, however, as even a better test. The sizes ordinarily used are 20 x 10, 18 x 10, and 16 x 10 inches. Care should be taken to have each row overlap the other by 2½ to 3 inches, and to interpose beneath the slate and roofing boards a layer of roofing felt. Lath in place of boards may be substituted if cost is an object; they fail, however, to give a uniform support to the slates, are easily damaged, and, further, they do not maintain an even temperature. The slates should be held in position by copper nails, never by iron; zinc and composition nails are sometimes used.

Lead and *zinc*, from their standard of durability and easy facility of working, are valuable; the latter is more extensively used than the former. Their disadvantage lies in the increased weight, which is, roughly speaking, from 18 to 26 ounces per superficial foot.*

Spanish tiles, made of clay and heavily glazed, are rapidly coming into use. They form a handsome roof, and although evidence may be given of the ability of the old tile to stand, time alone can tell for the present ones.† The quality of the clay and the smoothness of the glaze determine, to a large extent, the durability. The better glazed tiles are more hardened, and stand the test of bad weather longer.

Cement. For more than forty years the Germans have used extensively cement in the roofing of various buildings. The cement process is the invention of a German, Carl So Hæusler, of Hirschberg, Silesia, who claims that in Germany it can be constructed for from fifty to seventy-five cents per square meter (a meter equals thirty-nine and one-half inches), exclusive of the cost of boarding, the supply of zinc, and gravel necessary. Its introduction in this country has been very slow, as capital has not been sufficiently interested. This is to be regretted, however, since the application of such a roof renders it possible for every householder to enjoy the luxury of a garden roof without detriment or destruction to the rooms beneath.‡

Roof Drains. Draining of roofs is doubly important, not only as a sanitary measure, but for preservation of the timbers and walls as well; provision must be made for the properly securing of the hanging gutters, which may be of iron or tin—galvanized iron having the preference,—by adjustable fasteners, so spaced as to properly secure same from pulling out. Directly under the eaves, and at a fitting junction, should be placed the conductor, which may be round or square, and of plain or corrugated galvanized iron. The junction between the gutter and the con-

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* Of late we have had introduced tiles made of copper, and although none can be pointed out in illustrations, yet they are feasible in every way, and no doubt exists of their ability to stand. These, however, may prove very expensive.

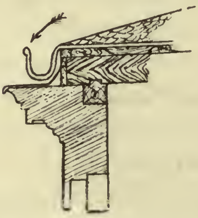
† It is a secret delight to architects to note the picturesque tile roof of the Casino Building, Leipsig, Germany, and through the southeast counties of England, that have so well stood the ravages of time and weather.

‡ According to the reports of the Town Council of Frankenstein, Germany, and reports furnished by the Government Architect, Thenne, of Glogau, the cement roof is considered the best, since it maintains a good standard of dryness, and the cost of keeping same in repair is very small.

ductor should be covered by a perforated cap, rising two and one-half to three inches, or by a network of galvanized iron, drawn wire, of such mesh as to prevent any material, dead leaves, mortar, and other matter from passing through and clogging up the conductor and trap.

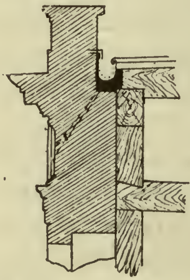
Basement or Cellar. Excavations for the cellar should be made of a depth not less than seven feet, or seven feet six inches, clear of all joists; the trenches should be six inches deeper than the cellar floor. The floor should receive a coating of good cement or concrete, not less than two to four inches in depth; Portland, Adamant, Roman, Kings, Warren, or Parian cements are to be recommended. These are admixtures of calcined gypsum and other substances, and are capable of receiving a good surface polish, which affords a better resistance to accumulative dirt and becomes non-porous. Beneath the floor there should be no sewage, water, or gas pipes, and the cemented floor may well be reflected upon the side walls for from six to eight inches.

FIG. 90.



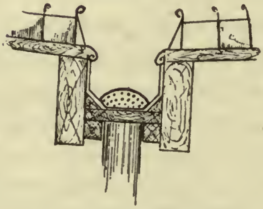
SECTION OF CORNICE AND RAIN GUTTER, OR CHANNEL.

FIG. 91.



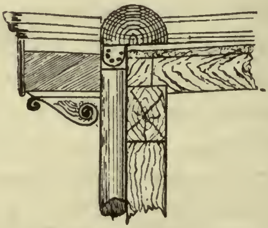
CROSS SECTION OF RAIN GUTTER.

FIG. 92.



RAIN GUTTER BETWEEN TWO ROOFS, WITH PERFORATED IRON GUARD.

FIG. 93.

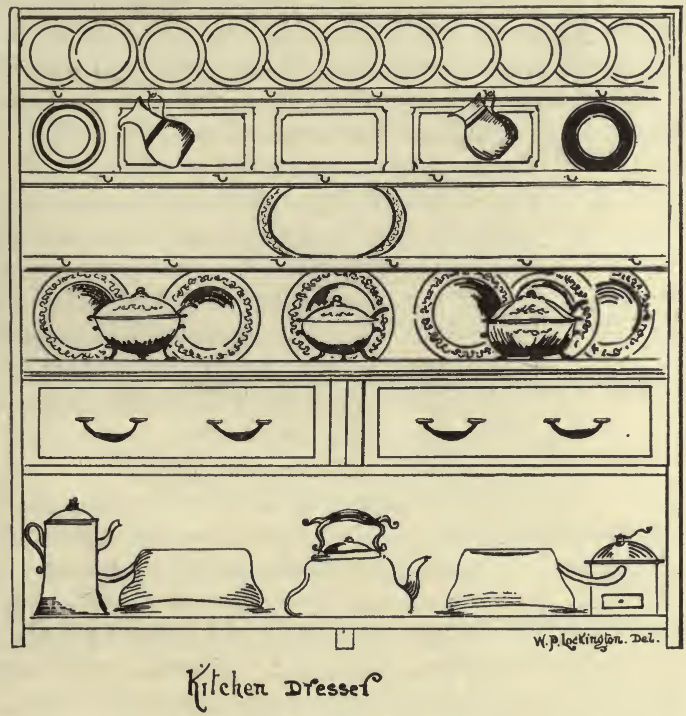


RAIN CONDUCTOR COVERED WITH GUARD OR CAP.

Where these directions have been adhered to no difficulty will be met in keeping the cellar dry, provided the walls contain a damp-proof course and the excavations have been properly made.*

Kitchen. Small kitchens are not to be recommended; 12 x 16 feet may be considered the minimum desirable. A wooden floor is objectionable by reason of its offering lodgment for all kinds of roaches, crickets, and kitchen-infesting insects; the penetration and retention of grease renders it even more objectionable. A floor that can be readily and easily cleaned, and one that will last, is cement.†

FIG. 94.



FRONT VIEW OF KITCHEN DRESSER.

If boards are used, they may be covered or stained.

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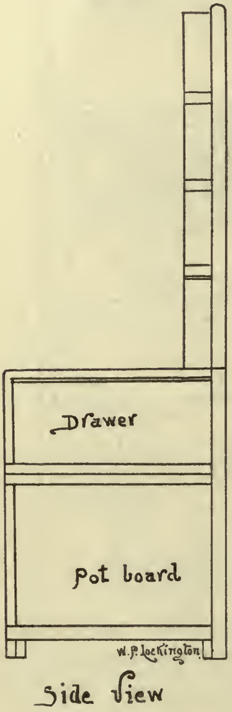
* For diagram of cellar and explanation of parts, see illustration under "Heating by Furnaces," page 321.

† The average domestic servant, however, dislikes a cement floor, and claims that it is cold.

See that the *range* is a good one, with proper facilities for securing an abundance of hot water; it should be set to the design of the architect, and under his supervision.

The kitchen *windows* should be broad and lighted with transoms, or falling from the top, as this serves to readily carry away heated air, smoke, and other objectionable gaseous products, and assists in maintaining proper ventilation. The *walls* should be of rough sand finish, or finished with a tile dado up to the height of four feet. Adamant or Keystone plaster, on the score of its quickly hardening properties, may be recommended as a good finish from the moulding or chair rail to the ceiling. Papered walls are not to be considered.

FIG. 95.



SIDE VIEW OF FIG. 94

A good *dresser* of one and one-half inch pine should be erected for the reception of china and crockery ware. This can be made in the form of Figs. 94 and 95; have three shelves for the dishes and plates to stand securely on their edges, while from the projecting ledges should be fastened brass hooks, upon which the cups, jugs, and pitchers can hang. The broad shelf beneath serves as a stand for tureen and vegetable dishes, beneath which may be two drawers, in sections, one for the ordinary table cutlery and small implements incidental to the workings of a kitchen, while in the remaining may be placed the kitchen linens. Directly under this will be seen what is termed the pot-board. This, in many well-kept houses, is blackleaded and polished in the same manner as the stove, and forms a depository for all pots, pans, and kettles. The entire structure is freely movable and should offer no lodgment for vermin. Two cupboards will invariably be asked for; these should be placed where it is warm, dry, and light. Where it is possible they should be so situated as to back upon the solid brickwork, and not too far from the range. Where it is necessary, give additional light by inserting in the wall or back part of the cupboard four of the Olivet patent glass building blocks.

Stairs. An open stairway is best, as nothing lends so much to the stately presence of a hall as a good stairway.

Unfortunately, this cannot always be given, owing to the small space allowed after cutting up the area of the lot for the respective rooms, and oftentimes the architect, much to his chagrin, is compelled to make a box stairway. The risers and treads, however, should be so arranged that the ascent or descent can be made with as little difficulty as possible—in fact, with ease and without an unnecessary bending forward of the body in going up, or throwing the body out of the perpendicular in coming down.

The *treads*—by this we mean the portion of the stairs on which the foot is placed—should be at least one and one quarter inch in thickness, with the edge nicely rounded with a half round nosing or moulding.

The *risers*, or part showing to the front and supporting the tread, should be one inch in thickness, with a depth or height of six and seven-eighths inches and not more than seven inches, with a tread of ten and one-half to twelve inches.

VENTILATION AND HEATING.

The utility of ventilation in the conservation of health has been one of the oldest traditions in all hygienic science. The fact that the air in which we live, if enclosed from the limitless space of heaven, rapidly became charged with noxious elements and demanded renewal was recognized long before medicine, even in its cruder form, was born. The knowledge which demonstrated the reason for the demand, which ventilation filled, has also reduced its problems to an actual science.

Literally, ventilation means " to fan ;" practically, it means continual displacement or dilution of the products of animal life, thrown off by the organs of respiration and cutaneous excretion, or other noxious agents of which we have already treated. Ventilation may occur by reason of natural laws which regulate the movement of gases, in which case it is entirely dependent upon such a multitude of extraneous conditions that it cannot be continuously effective nor under control.

Again, artificial means may be adopted to secure the proper supply of fresh air and removal of the effete products. These may be of the simplest construction or aids, in many cases mere permits, for ventilating processes to go on. Among these will be found so-called window ventilators, transom exits, and conduits from one room to another—all of questionable efficiency at best. These arise largely from the criminal ignorance or knavery of architects and builders, belonging to that fortunately diminishing class, who believe that a large enough opening, no matter where located, must of necessity secure efficient interchange of air.

The amount of dilution demanded will, of course, depend upon the amount of impurity which is being constantly added, and upon the purity of the diluent, at the same time considering the space occupied and the possibility of wall ventilation.

In estimating quantity the factors to be taken into consideration are: (A) The purity of the available air to be used for the dilution. (B) The noxious agents contaminating the chamber to be ventilated by dilution. (C) The maximum standard of impurity which is to be considered compatible with health. (D) The amount of the available air necessary to secure a constant atmosphere with a minimum of impurity.

(*a*) *The purity of the available air to be used for the dilution.*

It is necessary to say that it must be selected from the best attainable source. That contaminated atmospheres, no matter from what source the contamination, are to be rejected, and as these contaminants are variable or not constantly present all sources must be avoided where, after careful examination, it seems probable that noxious agents may gain ingress. Ventilation of one room from another is not to be thought of, and the utilization of air from halls, entries, and corridors, for the ventilation of rooms is to be condemned. Equally if not more dangerous is the use of cellar or subway air, or the air from under houses where no cellars exist. Where any difference exists the air should be taken from that point containing the least suspended matter and air from large yards selected in preference to street air; proximity to water-closets, cesspools, or other courses of air pollution is to be avoided. Where feasible air should be admitted from the sunny side, as it will be warmer and proportionately less damp. It should be admitted on the side of the house against which the prevailing winds impinge, as these favor the ingress of air on that side and would by the diminished pressure retard entrance on the other side.

When the air is delivered through the house by conduits or utilized for heating, to be considered later, it is admitted all from a single inlet, the height from the ground becoming important, as does also the immediate surroundings of the inlet. It should be from eighteen to twenty inches above the soil level, screened to prevent ingress of birds, etc., and the earth immediately beneath the point of inlet should have abundant short vegetation; this will arrest much of the dust precipitated from the surrounding air, which, if a bare or paved space be immediately beneath the inlet, will be swept in by the first gust of wind. In the winter the vegetation cannot, of course, so act, but the almost total absence of dust renders it unnecessary. It was at one time believed that air could be brought down from some altitude and trapped, as it were, into buildings, but "back currents" are so likely to form that even forced draught fails to secure an abundant ventilation in such cases. As to the impurities already described as present in air, but few occur in air brought in under the conditions above given; those occurring are usually in such small quantities as to scarcely demand attention except as computing factors in estimating quantity of air demanded. Carbon dioxid is almost constantly present in from .1 to 1 per thousand volumes, rarely the latter; hence if it be desired to dilute to this point it will be necessary to completely displace the entire vitiated air of the room as often as a single respiration is completed in its atmosphere. A very important factor is humidity, and this is materially altered by heating, the change being brought about in two ways: (1st) If a volume of air, say 1000 cubic feet at 32 F., be raised to 72° F., the volume under the same barometric pressure becomes 1082.8; as the gross amount of moisture remains the same, its relative percentage is radically altered. (2d) Again, if the atmosphere be saturated at 32° F. and raised to 72° F., the quantity of water demanded for saturation at the higher temperature materially changes; thus at 32°F. the quantity of aqueous vapor necessary to secure saturation of one cubic foot of air (the dew point) is 2 grains, while at 72° F. 8.5 grains will be required for an equal volume.

(*b*) *The noxious agents contaminating the chamber to be ventilated.*

These are largely the products of the occupants of the room, and have been considered while treating of air, to which the reader is referred. Occasionally foreign matter suspended, as in the planing mills or other industries, or in the gaseous form, as in mines, will demand removal; in such case special provision must be made.

(*c*) *The maximum degree of impurity which is to be considered compatible with health.*

Of organic matter this may be considered as the least possible quantity appreciable to the senses, the basis usually given by architects and sanitarians, but as the discernibility of different individuals varies to such an enormous degree, such a rule cannot be of any actual value, for what is barely endurable to one becomes unendurable to another, and is imperceptible to a third.

Air of a comparative purity contains .1 milligram or less of albuminoid ammonia and less than .09 milligram of free ammonia per cubic meter. If these data were readily attainable, which they are not, we could estimate quantity on the basis of organic matter.

As already stated, accurate methods for determining the quantity and composition, which, no doubt, varies enormously, of organic matter are not available, and hence, though such knowledge would be of incalculable benefit to the human race and a vast aid to the calculations of sanitarians, we must resort to other methods for estimating the degree of impurity. The number of bacteria present might at first appear to offer a slight basis, but closer observation shows the fallacy of the theory. Thus, air constantly containing the smallest number of pathogenic bacteria, *e. g.*, the bacillus of tuberculosis, or typhoid fever, or anthrax, must be absolutely dangerous, no matter how few the number of such organisms may be. On the other hand, an inestimable number of non-pathogenic microbes does not of necessity disprove the healthfulness of the air in question.

Furthermore, the introduction into the room of enormous quantities of bacteria may temporarily occur from a dust-cloud or the agitation of a single dust and dirt-laden garment.

As a last resort, undesirable as it is, we are driven to estimate quantity upon the amount of carbon dioxid which is present. As the difference between the amount of carbon dioxid in the available air and the air of the chamber to be ventilated represents the contamination, it must of necessity, all other things being equal, afford a fairly reliable basis upon which to calculate the quantity. This assumes that all the carbon dioxid present is the product of life, and makes no allowance for contamination due to lights or introduced from some industry, as in soda-water manufactories. The quantity of carbon dioxid present should not exceed in desirable air .75 per 1000, and if the amount in the available air used for dilution is less than .35 per 1000, good ventilation will demand that the minimum of impurity in the apartment ventilated should not exceed twice the quantity present in the incoming air. Thus, if the available air contain .03 per cent., the apartment should contain no more than .06 per cent.

The above factors being known, the quantity of air demanded for ventilation is calculated by ordinary arithmetical formulæ. The sanitarian may, however, be aided by remembering that there is to be allowed for each

Adult male, per hour,	3500 cubic feet.
“ female, per hour,	3000 “ “
Children, per hour,	2000 “ “

As the proportionate contamination is greater for the adult, the mean will be slightly greater than one-third of the sum of the three, or about 3000 cubic feet per hour.

Methods by which ventilation is secured.

As the ideal of ventilation is the entire removal of noxious materials as soon as formed, and as these rise from the body by reason of their increased temperature and the surrounding heat currents, a method of ventilation which would secure the constant upward flow of the air with the fresh air inlet through the floor would be perfection itself. Such a method is not, of course, attainable, but the nearer we can approach it, the better the results from a sanitary standpoint. In summer open windows and doors afford, in dwellings, means of ingress and egress for ventilating currents; but in winter, for obvious reasons, we must secure other means. In large audience halls, theaters, and manufactories the windows and doors cannot be depended upon to remove the enormous quantities of effete material; so artificial means must be utilized, as will be explained later. As ventilation is largely brought about by air currents, and as air currents are, under natural processes, established by heat, the latter is depended upon in dwellings to secure ventilation.

HEATING.

Heating or warming of any given space is dependent upon the transmission of heat by one of three methods, *radiation*, *conduction*, or *convection*.

Radiation. By radiation we mean the heat which travels in straight lines from its source, but little affecting or affected by the air through which it passes. The glowing coals of the open grate afford the best example of radiant heat source. It seems necessary for efficiency, however, that the source be of, at least, a dull red heat; that is, it must be at a very high temperature, although at all temperatures a certain amount of radiant heat is given off.

By *conduction* we mean the transmission of heat from a particle of matter to its neighbor without the necessary intervention of current or the movement of either particle. Thus the hot water, or steam, circulating in a pipe heats the inner surface of the metal, and by conduction the heat passes from atom to atom until the surface is reached and the air becomes heated by the atom in immediate contact with the iron receiving the moving force.

Convection is the carrying of heat by the currents which it produces. The process is really but one form of conduction, as the heat *per se* is not modified by the movement and is the passive factor in the current which it established.

Technically, heating is said to be accomplished by *direct radiation* or *indirect radiation*. Of the former the stove affords the best example. The heating is accomplished without any special consideration for securing ventilation; it is heating without ventilation, the same air, by convection, being heated over and over. Ventilation, if it occurs, is an incident, and not a part in the process.

By *indirect radiation* is meant the introduction of air already heated, the heating being accomplished elsewhere than in the room itself. Various combinations of the two methods have been made, and a third form, known as *direct-indirect radiation*, has been introduced. By this is meant that the source of heat is within the apartment and is therefore radiating or heating direct (really heating by convection), and at the same time fresh air is being introduced through the heating apparatus, securing indirect heating.

Open Fireplaces. These heat almost exclusively by radiation and are the only appliances in which this method forms the essential heating factor. Not only do open fireplaces heat by direct radiation, but, by inducing a current of air in the flue, heating by convection is prevented, and ventilation abundantly secured. Much has been done of late to make open fireplaces generally available. The old forms were very extravagant in the use of fuel, the larger quantity of heat going up the chimney or flue, at least 94 per cent. of the available heat being lost in this manner. A few innovations of late years have, however, increased the heat yield of grates: (1st) The rifle-back chimney, (2d) floor-fed flues, (3d) under-fed fires, (4th) draught regulators, (5th) water-backs with circulating apparatus attached.

(1st) Rifle-back flues, or chimneys, consist of a long projecting ledge of firebrick directly over the fire, extending forward from three to six or more inches, depending somewhat upon the depth of the fireplace. This horizontal projecting ledge becomes heated, in the most approved forms, to almost redness, and thus forms a second source for radiation. Instead of firebrick asbestos may be used. The firebrick in some forms of rifle-back is made corrugated, thus increasing the radiating surface; in other forms the back is so set that its angle may be altered at will, a factor theoretically valuable, but practically it has been found that there is great annoyance from breakage.

(2d) Floor-fed flues or grates are grates or fireboxes placed on a level with the floor, the draught being supplied from beneath the floor of the room to be heated, and the ashes passing by a conduit in the wall to a proper receptacle in the basement, or occasionally, in suburban and country houses, to ash-pits on the outer wall. The advantages of this form of grate lie in the lowness of the heat source, the freedom from dust, as by a mechanical stoker the ashes are dropped without ingress to the room as it occurs in the ordinary grate, and the perfect control of the under-draught regulates the supply of air and hence the rate of combustion, thus lessening waste. There is no reason for not combining the rifle-back and floor-fed grates, or the two with the next form.

(3d) Under-fed fires or grates possess additional commendable qualities. As already stated, radiation is most efficient where the heat is high, red, or approaching redness, an ideal being a bed of live coals. In under-fed fires it is the idea to supply the fresh fuel at the bottom, carrying the live or red coals to the top. In order to accomplish this a special form of shovel is required, by means of which the coal is supplied immediately beneath the burning fire, keeping the hotter layer on the surface. These grates have not been used in this country, but in England have given very great satisfaction. The greatest difficulty, however, arises in securing satisfactory stoking, as without great care and some experience the fire cannot be maintained.

(4th) Draft regulators are supplied in some open fireplaces both above and below the fire, and in some forms a shift circuit is made behind the grate, thus lessening the current through the fire and diminishing combustion. The simplest regulator consists of a hood made of sheet-iron so fitted as to close the fireplace above the fire or grate, or to close the grate below the fire; in the former instance the entire draught flows through the burning fuel and hastens combustion, but carries practically all the heat up the flue. If placed below the grate the air current through the fire is reduced to that flowing between the bars and a dull, slowly burning fire is secured. Chimney-draft arresters, or dampers, are sometimes placed above the fire, but these are not to be advised, as they may, by injudicious use, be made to so occlude the flue as to lead to pollution of the atmosphere of the room by face currents, thus converting the fireplace into a stove with open door and closed damper. The danger may be lessened, although not removed, by only permitting a damper which, when entirely closed, cannot be made to occlude the draft. Circuiting flues are occasionally used to lessen chimney waste. These are regulated by dampers and the escaping current from the fire is made to partly return to a lower level, and may be here passed close to the surface of a mantel or fire-board heater, and heating by convection secured. Such flues are regulated by suitable dampers.

(5th) Water-back fireplaces have many forms with great differences in construction, although containing the same essential features. Back or over the grate, sometimes at the sides as well, a metallic chamber is arranged which contains a thin vertical layer of water so placed, and having suitable connections with a circulating water system above and in front of the fire and flue, as to secure a small hot-water circulating system to heat by convection or direct radiation. Some of these forms of water-back grates may, in the future, be made practically available, although at present they are disproportionately expensive.

Objections to Open Fireplaces. Aside from the enormous waste in fuel which takes place when open fireplaces are used, they do not offer an available quantity of heat for very low temperatures. After a fair trial of double fireplaces (*i. e.*, fireplaces arranged back to back) in small army hospitals, Billings concludes that very fair heating and excellent ventilation may be secured where the external temperature is not below 30° F. Below this point even the best forms do not efficiently heat the room, as the cold air entering the room maintains too low a temperature by its continuous dilution of the warmer air present at a given time. As the Northern, Western, and Central States of the Union are extremely liable to lower temperature than 30° F., fireplaces will remain in these regions one of the best ventilating accessories to a heating plant, but cannot be depended upon to secure satisfactory warming.

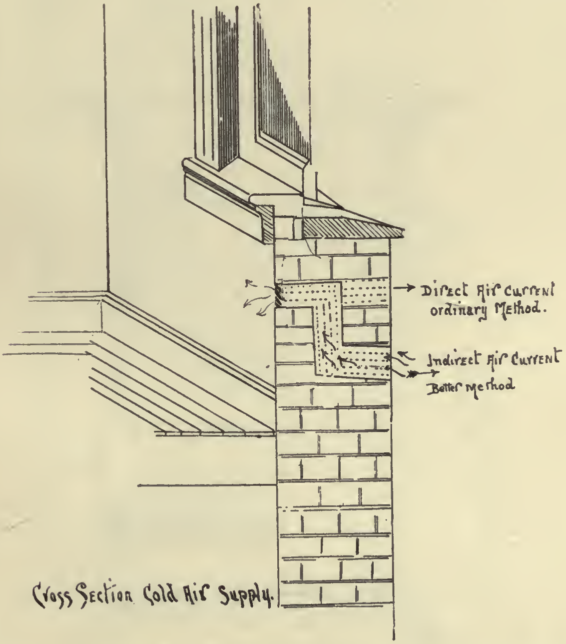
Of the fuels to be used in open fireplaces, anthracite coal offers the most available heat with the least expense, while wood and bituminous coal give that cheerful, satisfying sense of gratification not supplied by any other means of heating. Not infrequently, in the presence of such fires, one forgets the face-roasting and the back-freezing accompaniment of open fireplaces in cold snaps. In England, where extreme cold snaps are rare, the open grate is very generally used either alone or combined with steam or furnace heat. France also uses the open fireplace. Instead of soft coal, fagots of coal and charcoal are used, and occasionally wood. Where natural gas can be had, as in Western Pennsylvania, West Virginia, and Ohio, firebricks are placed in open grates, the gas admitted below and burned through the broken bricks; this heats them to redness and affords an abundant supply of radiant heat. The temptation to dispense, either altogether or partly, with the escape flue must be avoided, as the ventilating element is thereby abolished and the apartment dangerously contaminated by the products of combustion.

Stoves. It has been truly said that there is no well-founded objection to any form of heating which the stove does not possess. With the possible exception of expense, the statement is axiomatic; if, however, sickness attributable to the bad ventilation of stove-heated apartments be computed against their apparent inexpensiveness, stoves will compare unfavorably with all other forms of heating.

Stoves heat almost exclusively by convection (direct radiation), heating the same air over and over, utilizing but a very small quantity for draft, and thus demanding but a scant air supply to the room. As ordinarily constructed, loose joints, pervious casting, and badly fitting flues secure abundant air contamination. Technically, stoves heat by direct radiation, truly, however, they radiate but little unless heated to redness, something not to be thought of, as organic matters in the air are decomposed by contact with the superheated surface and soon produce an abundant atmospheric odor peculiar and easily recognizable as arising from stove-heated surface. Superheated cast iron leaks carbon monoxid and carbon dioxid, while wrought iron cracks and breaks joints under any very high temperature. Another fault constantly present in stove-heated rooms is deficient moisture. A cubic foot of air admitted to the room contains, we will assume, at 40° F., three grains of aqueous vapor. If the temperature be raised to 70° F. the same quantity of moisture will be present, but the quantity demanded to make the relative humidity the same at 70° F. which it was at 40° F. will be over twice the amount present at the lower temperature, or about eight grains of aqueous vapor. If the additional moisture be not supplied, the excessively dry atmosphere abstracts a quantity from the skin and mucous membranes, more particularly the latter, and is therefore not only uncomfortable, but absolutely inimical to health.

What has been said of stoves applies to any apparatus which heats a room without, at the same time, affording some facilities for ventilation. Stoves are made which are presumed to accomplish ventilation in various ways. They are constructed like open grates, many exactly resembling an open fireplace; but none of these are without the fatal damper or short horizontal flue or return current flue, which cuts off the draft or lessens it, and thus creates all the dangers, although often to a lesser degree, of the common form of stove. If the flue or damper arrangements do not accomplish this, the stove is no economy and uses as much fuel as the open fireplace, it is less attractive, and, at its best, less safe. A stove is made which permits of a cold and warm air register, bringing in fresh air and heating it in a jacket, much as does the furnace, but such a stove is not so good nor cleanly as the furnace, and is to be again condemned, as it possesses all

FIG. 96.



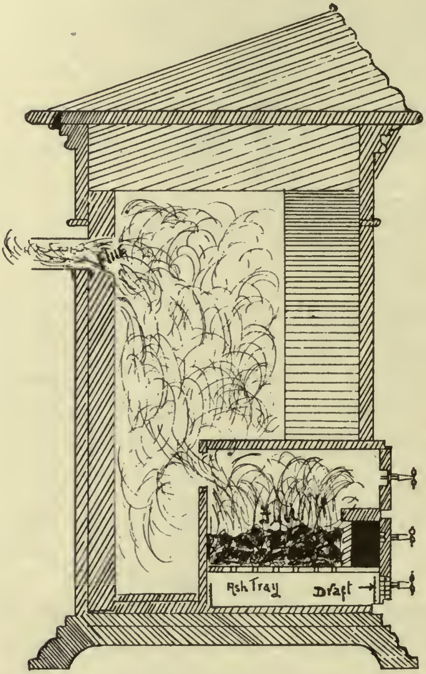
FRESH AIR REGISTER.

Form applicable to any method of heating by what is known as direct radiation, such as stoves afford, or combined with a steam or hot-water heater, may constitute a form of the direct-indirect heating method.

the dangers common to its class in a less marked but unavoidable form.

On account of its cheapness the stove will undoubtedly remain a factor in heating until something as cheap and as generally useful can be devised to supplant it. If, therefore, it be a necessary evil, how shall we best entertain it? It had best be made of Norway iron and lined with firebrick, or its equivalent, fire-lining. This makes the supply of heat fairly constant, prevents sudden rises and falls of temperature, and lessens the tendency to superheating; with a constant element of heat, a constant draft, small though it is, will thus aid in securing ventilation. Exit flues for the hot and foul air must be secured, and cold air registers supplied. Wood or, better, anthracite coal or, best, gas may be the fuel; if the latter, it is to be used as already spoken of under open fireplaces. On a large scale, with abundant fresh air inlets and foul air outlets, the German stove possesses many advantageous points.

Fig. 97.

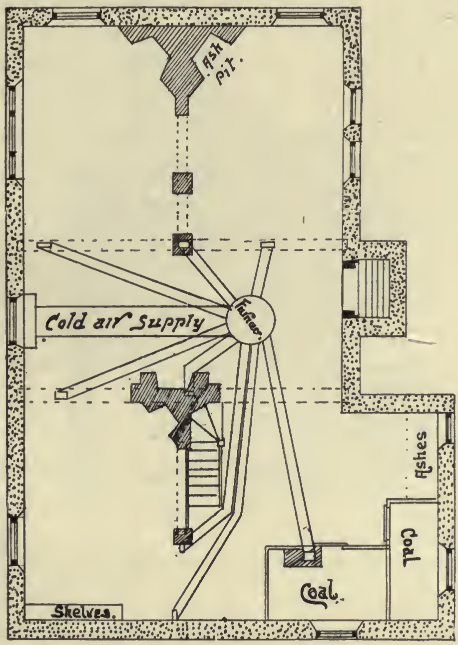


Cross Section of German Stove.

This usually stands in the corner of the room, and although made of brick internally, is faced with porcelain tiles and sometimes richly ornamented with terra cotta and hand-painted work. There is probably no form of heating appliance which, in the absence of ventilation, is so economical, and it is probable that it might be used with efficient ventilation.

Furnaces. Hot-air furnaces in this country afford the most common method of heating. Technically, they heat by indirect radiation, and hence afford ventilation. Billings considers that the greatest difficulty in hot-air furnaces, as at present used, is the disproportionately small heaters for the work to be accomplished.

FIG. 98.



PLAN OF CELLAR, SHOWING LOCATION OF HEATER, ETC.

The location of the furnace should be central and sunk ten inches below the cellar floor, with a margin around, as a receiver for the cinders, and better feeding for the fire. The cold-air supply, either round or square, should extend to the window, and be supplied with a section or supply-screw damper for temporizing the supply of cold air. This is important and should be regulated according to the change of wind. Where it is possible see also that the coal bin is placed in the rear of the house, best under any circumstances have it pitched directly under one or more of the basement or cellar windows. This renders the delivery of coal easy and does not locate the bin in the dark. There should be a bin each for the kitchen and furnace coal. The trap-door and steps from the cellar to garden is shown to the right and in front of the furnace. Shelves are provided for the storing of liquids, etc., and here the refrigerator will find a good standing-place in winter and summer.

He advises as best, and equally economical, comparatively large heaters, possessing abundant radiating surface and not requiring that the fire-pot be heated to redness in order to secure the necessary degree of warmth. Superheating leads to breaking of joints and leakage of the products of combustion into the heated air. Cast-iron furnaces are presumed to be less safe in this respect than wrought-iron, tile, or brick ones; but it is not probable that with proper construction, a thing rarely attained in any of them, one offers much advantage over another.

The furnace may be located as in Fig. 98. Here it will be seen that the furnace is set as near the center as possible, as this gives an equal proportion of pipes for the distribution of the heat. When applicable, it is probably best to locate the furnace nearest the side of the house upon which the prevailing winds impinge. There should be a cold-air supply-pipe, as shown in the illustration, for carrying fresh air to the heater. The walls of the pipe or inlet should be air-tight in its passage through the wall of the cellar and through the cellar itself, in order to exclude ground-air or the vitiated air of the basement. Heat travels slowly after leaving the stove and entering the hot-air pipes; therefore, where the lines are horizontal or nearly so, there should be an elevation of not less than one and one-half inches to the running foot. Hence the necessity of setting the furnace down in a slight pit of ten to fourteen inches, where the cellar is low.

All the rooms standing north, northwest, or northeast should have the advantage of the greatest heat, therefore the short pipes should lead directly to these, as the wind blowing from those points tends to rapidly force the heated air into the rooms standing south, southeast, or southwest.

Every precaution should be taken to see that the hot-air flues are never placed in an outer wall, where it is possible to avoid it, as this only causes an unnecessary loss of heat. But where forced to carry them into the outer wall, double tin flues should be used with a sufficient air-space between the inner and outer flues to economize the heat.

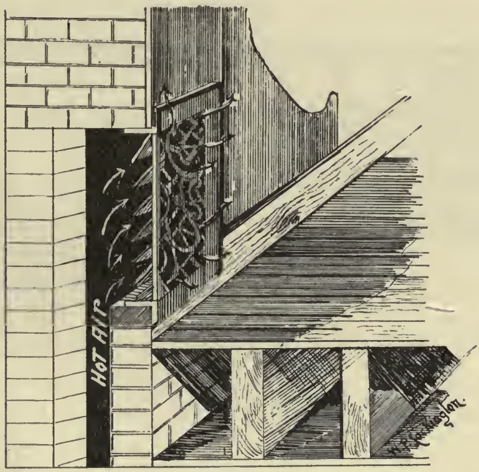
The upper stories should be heated independently of the first-floor supply-flues, and it must be borne in mind that the first floor is the most difficult to heat.

In placing the registers on the first floor, it is better to place them on the most exposed side of the room, even though to do so involves the expenditure of a greater length of pipe.

While many advocate the locating of the register in the floor, yet it has its side of objection, since it is always liable to swallow up a great portion of the dust from the carpet sweepings, etc., which cannot be easily avoided.

In locating wall registers care should be taken to have these of ample proportions. The following table will afford the necessary information and at once determine the size required:—

FIG. 99.



WALL REGISTER, SHOWING RELATION OF PARTS.

If fresh-air inlet, as indicated while considering stoves, be placed immediately over this, abundant facilities will be secured for ventilation. It will be necessary, however, to place a shutter in the fresh-air inlet, as if both be open a circuit may be formed between them, the hot air not diffusing with the general atmosphere of the room.

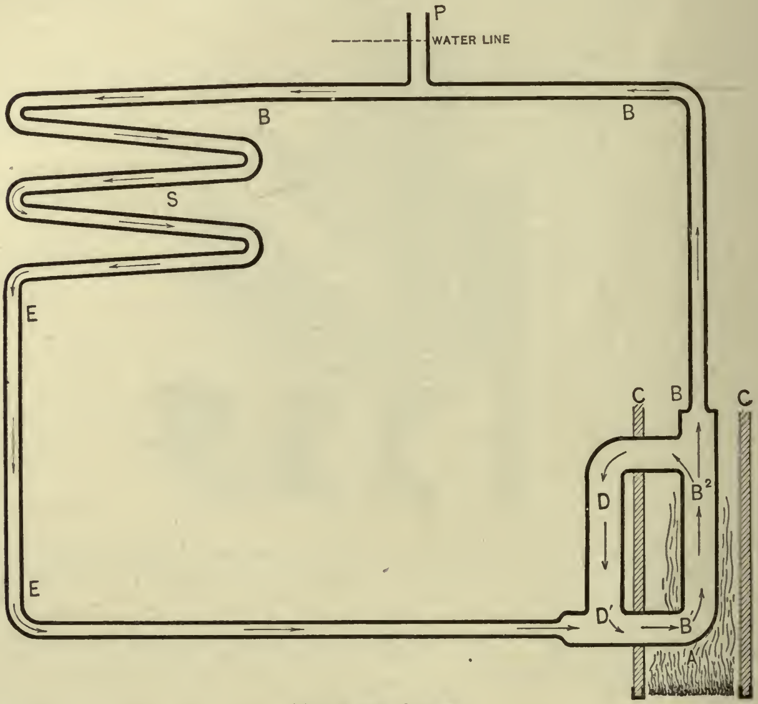
FIRST FLOOR.

SIZE OF ROOM IN CUBIC FEET.	SIZE OF PIPE.		SIZE OF REGISTER.	
	If Round.	If Square.	If Round.	If Square.
Less than 1500	7 inches	4 x 9 inches	9 inches	7 x 10 inches
1500 to 2000	8 "	4 x 12 "	10 "	8 x 10 "
2000 " 3000	9 "	4 x 16 "	12 "	8 x 12 "
3000 " 4000	10 "	4 x 18 "	12 "	9 x 14 "

For all second and third stories the pipes and registers should be diminished in proportion, and for halls in dwellings an 8 x 10 inch register will be sufficient, unless, of course, the hall is of huge dimensions, when the same calculations can be applied as directed for rooms.

Steam and Hot-water Heating. These two methods have become very generally used in houses a little more pretentious than the furnace-heated houses. Large buildings are almost exclusively heated by steam, hot water being reserved for dwellings, hospitals, green-houses, henneries, etc. The hot-water system requires great care in setting, as a very little neglect of the principle involved may preclude the working of the entire

FIG. 100.



HOT-WATER SYSTEM.

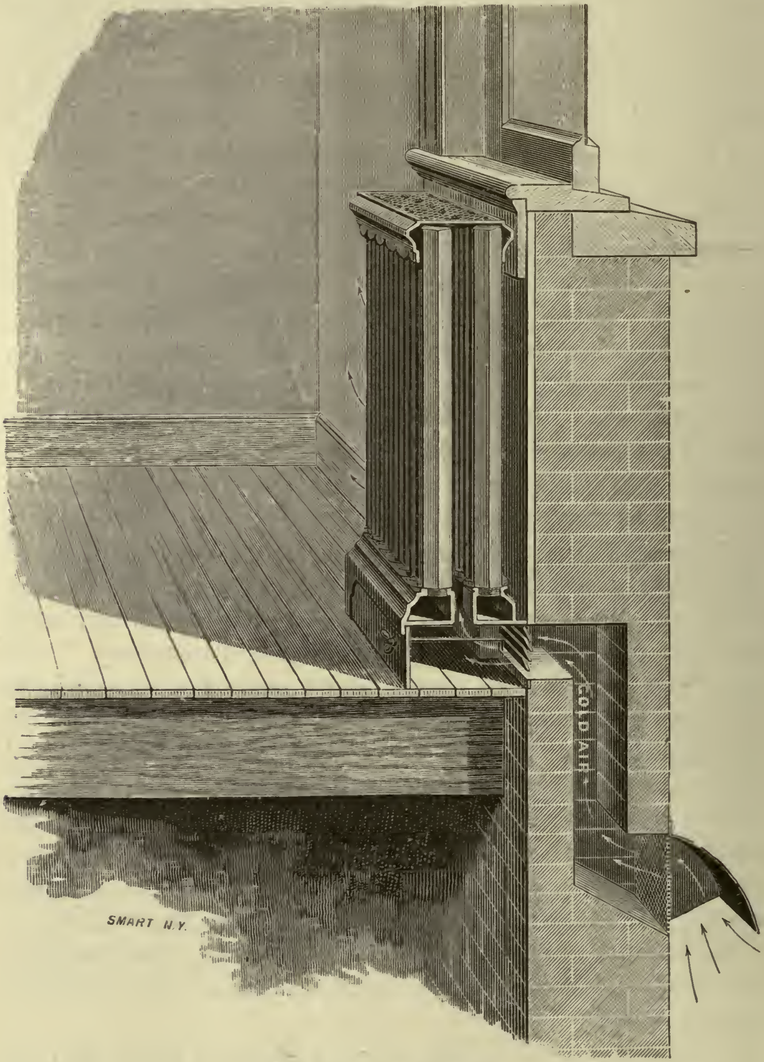
B^1, B^2, D. D^1 show boiler heated by fire at A. C, C show furnace line, so that D to D^1 is without the fire-box and constitutes a short-circuit system. As the heated water rises from boiler connection at B, it passes along the efferent tube, B, B, B, from which rises the stand-pipe, P, which marks the height of the water in the system. When the heated water reaches the radiator, S, the cooling of the current leads to a continuous increase in the weight of the column, and hence favors the return flow through the afferent pipe, E, E, entering the boiler at D, to be again heated.

system. Exactly what this principle is can be best illustrated by the accompanying figure.

The success of the system is dependent upon a minimum of friction in the currents and the placing of the radiator in such a manner as to secure a constant downward flow of the cooled water. It is simple enough for a single radiator, but where a large number are used on different floors at varying altitudes, in cool places and sheltered places, and where the working of the entire system is dependent upon each individual part, many difficulties will be encountered. If properly constructed and the heating planned for when the house-plans are made, this system is probably the most economical, both in fuel used and repairs demanded. Where these precautions are not taken, or where old buildings are to have modern methods applied, or in very large buildings with greatly varying altitudes, steam-heating is more applicable. In steam-heating such great care is not necessary for planning the system, and as a great percentage of plumbers and gas-fitters are acquainted with steam-fitting, extra skill is not so much needed. It is not necessary that every part of the system be planned to the line, as the currents of steam travel rapidly and are backed by pressure to secure forward movement. In steam-heating the boiler may be on any level, and battery arrangement of radiators is not necessary. The higher pressure and the closed circuit make the possibility of explosions to be considered, although modern safety appliances have reduced this danger to a minimum. The accumulation of sediment in the boiler and many annoyances for repairs are possibilities more constantly associated with steam than hot-water heating. Beside the indifferent knowledge necessary to secure efficient heating by steam, the cheapness of the supply in manufacturing and industrial establishments makes it the most readily available system. Used or exhaust steam may be passed through the heating system and applied exactly as though coming directly from the boiler.

In the distribution of heat the two methods, direct and indirect radiation, are used. On account of its cheapness the direct has been most applied. It is the same method of heating as the stove and is open to the same objections, except that the direct steam or hot-water radiator does not utilize even a little bit of the air of the room in necessary currents. As it is absolutely necessary to ventilate in order to secure satisfactory heating,

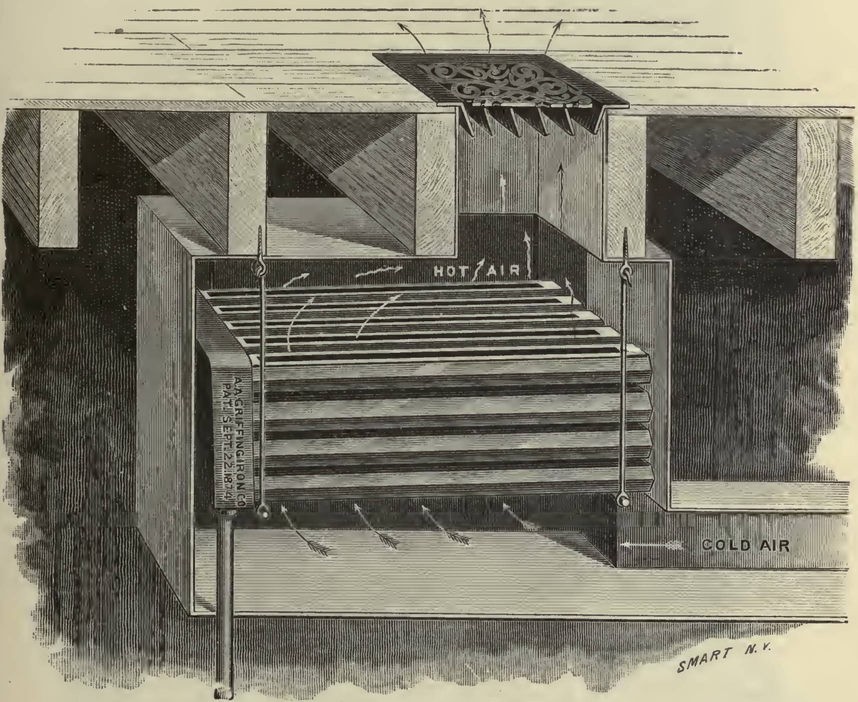
Fig. 101.



Direct-indirect Heating.
Radiator located under a window and fresh air admitted through perforated bottom and between the radiating surfaces

no form of direct radiation should be tolerated. A form of heating in which the faults of the direct method are mitigated by securing the entrance of air through the radiator is known as the *direct-indirect* method. The theory involved is shown in the accompanying illustration. Many forms of radiator and inlet are constructed on the principle here shown. In some, the air current is carried through between a battery or succession of radiating surfaces; as this might at times overheat the room, the radiating coils or columns are so arranged that one or more may be cut out of the circuit, or the steam may be turned on in only a few of them. In some houses architects plan the fresh-air inlet, so arranged that it can be closed by a damper, the idea being that when no one occupies the room, the indirect heating may be turned off and an economy of heat secured by allowing

FIG. 102.

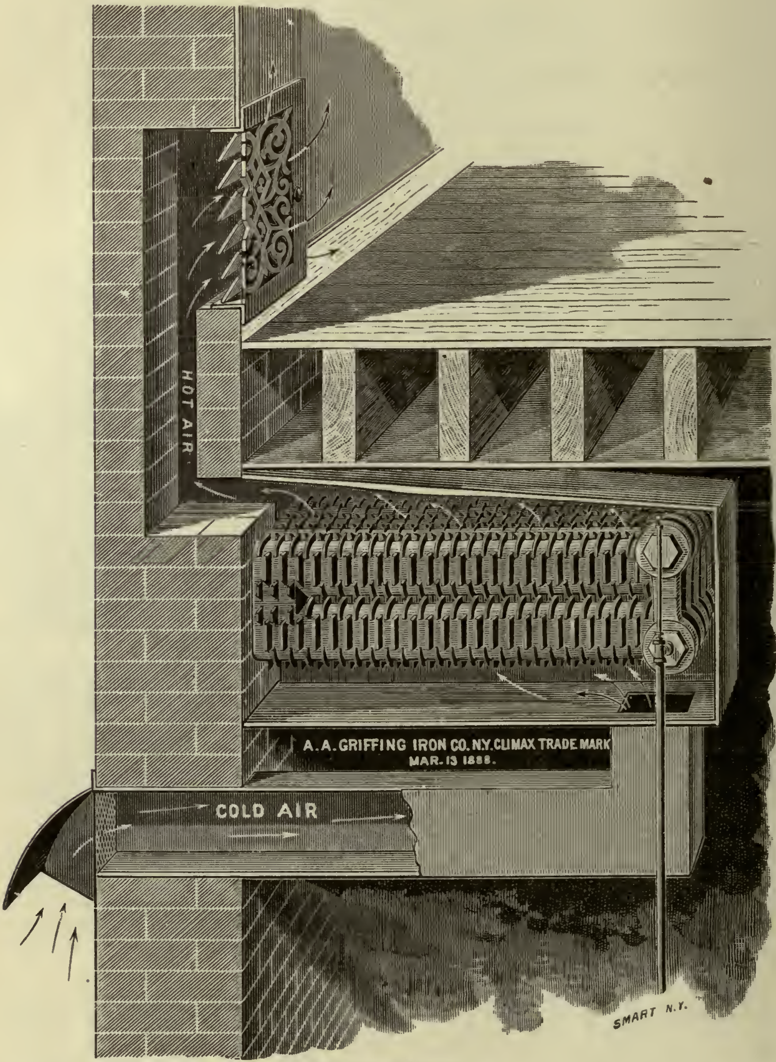


INDIRECT HEATING BY MEANS OF A FLOOR REGISTER.

A form of register very commonly placed in halls and stores. As dirt will be constantly dropping down the register and lodging in the heat box, covering the radiator and diminishing its heating power, such registers are objectionable where they can be avoided. The walls of the air conduit and radiator box must be air tight in order to prevent cellar or vitiated air from the space beneath the floor gaining ingress to the register and the room above.

only direct radiation. While this can be done it not infrequently occurs that the fresh-air inlet is not opened for several hours, if

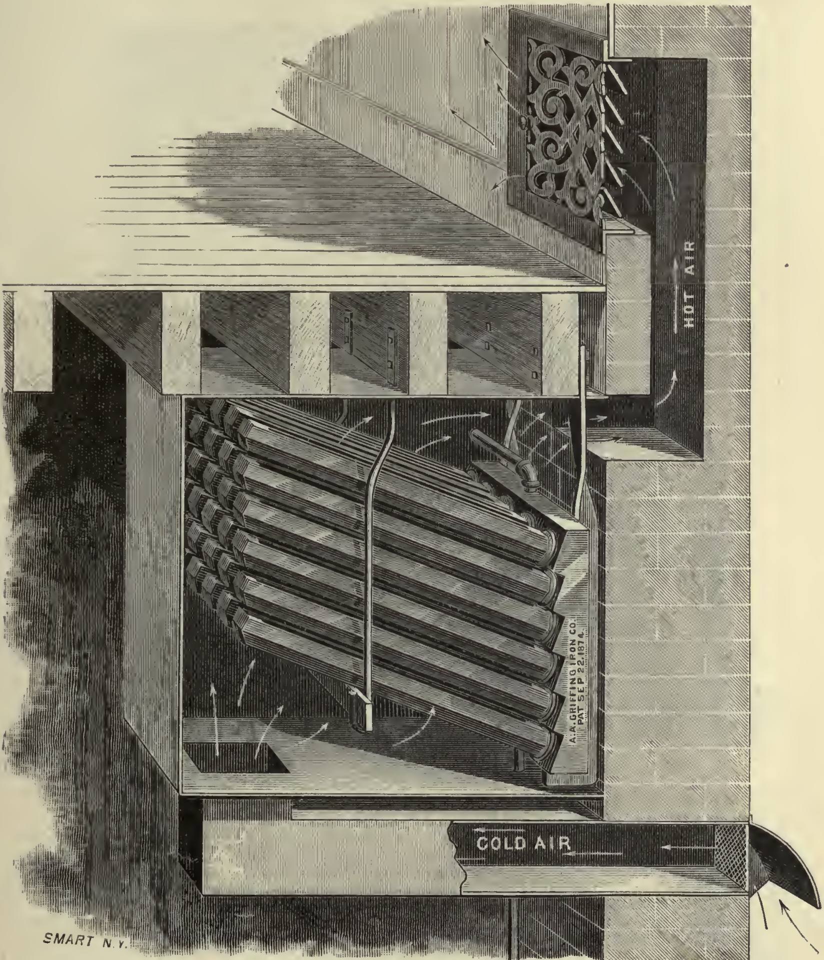
FIG. 103.



INDIRECT HEATING.
Same as preceding figure, except that corrugated or pin-barrel radiator, either steam or hot water, is here shown, combined with a wall register.

ever, and the good intention becomes a danger. Instead of the cold-air inlet ascending through the wall to the radiator, it is recommended that it begin externally just below the window-sill and pass downward through the wall to the bottom of the radiator. It matters but little which course be taken, however; from above

FIG. 104.

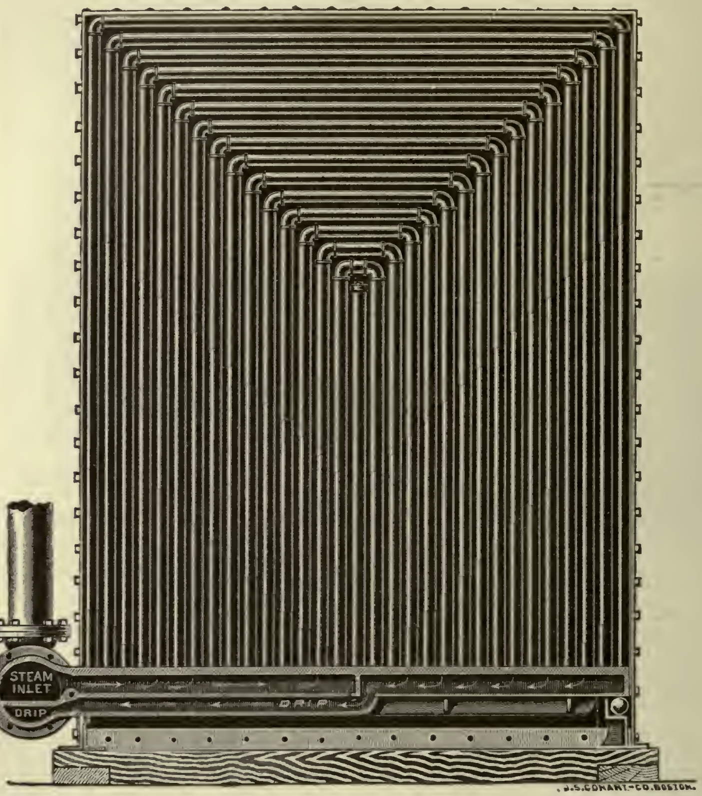


INDIRECT HEATING BY WALL REGISTER AND FRESH-AIR WALL CONDUIT THROUGH OBLIQUE RADIATOR.

snow, rain, and dust may descend much more likely than for any similar process to occur from below.

Indirect Radiation. Many forms of this method are in use, but the essential feature of them all is to heat the air by passing it through a radiator situated elsewhere than in the room to be heated. These radiators or heaters may be in the cellar or in an adjoining building, or immediately under the apartment to be heated. The accompanying cuts show the methods for locating the radiator near the rooms to be heated.

Fig. 105.



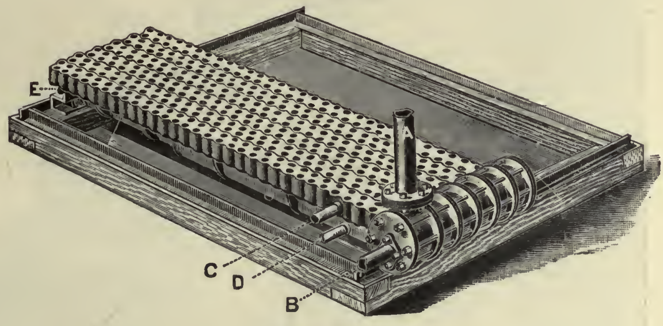
Indirect Radiation.

One of the best radiators for the indirect method of heating large buildings. The base is made of cast iron and the pipes of the best steel. Steam enters through vertical inlet pipe, passes over through the sections and down through the drip pipe or conduit at the bottom. The sections are tested at 150 pounds hydraulic pressure, to insure tight, non-leaking joints. The entire radiator is set on brick and covered externally by some non-conducting insulator, such as asbestos, magnesia covering, or plaster and brick. A fresh-air inlet flue as directed for furnaces must be so constructed as to secure an abundant supply of pure air. The heated air is conducted to the rooms above, as already directed while considering furnaces. By a specially constructed mixing damper, the cold or fresh air may be circuited directly from the inlet to the distributing flues and any degree of heat thereby secured.

This method is applicable in dwelling houses and small buildings, but not so useful as is the heating of air on a much larger scale and bringing it to the room through wall conduits and registers. The steam or hot-water coils, preferably the former, are placed in the cellar. Although many forms are used, that shown in the illustration meets all the requirements. So advantageous is this method that enormous buildings are heated in this way, and it seems applicable to entire blocks, for example, supplied from a central depot. As air currents and the direction of wind materially influence the ability with which even heat moves large bodies of air, in the heating of hospitals, halls, or theaters, etc., it has been found advantageous to force or drive the heated air when wanted. This is accomplished by large fans made expressly for the purpose. Two methods are applied: (1st) *the exhaust system;* (2d) *the plenum system:*—

(1st) *The exhaust system.* By this method the air of the apartments is extracted by suction, and the pressure of the external atmosphere is depended upon to secure the entrance o fresh air. This the method undoubtedly accomplishes, but it assumes that all the air which enters the room comes from a desirable source, and arrangements are made for such entrance. As the pressure of the external atmosphere is universally distributed, air will enter the area of reduced pressure from the most accessible point. It may not, therefore, be a desirable source, and may be merely the contaminated contents of an adjoining apartment. It was believed that the exhaust system, combined with the direct-indirect radiator, would secure efficient

FIG. 106.

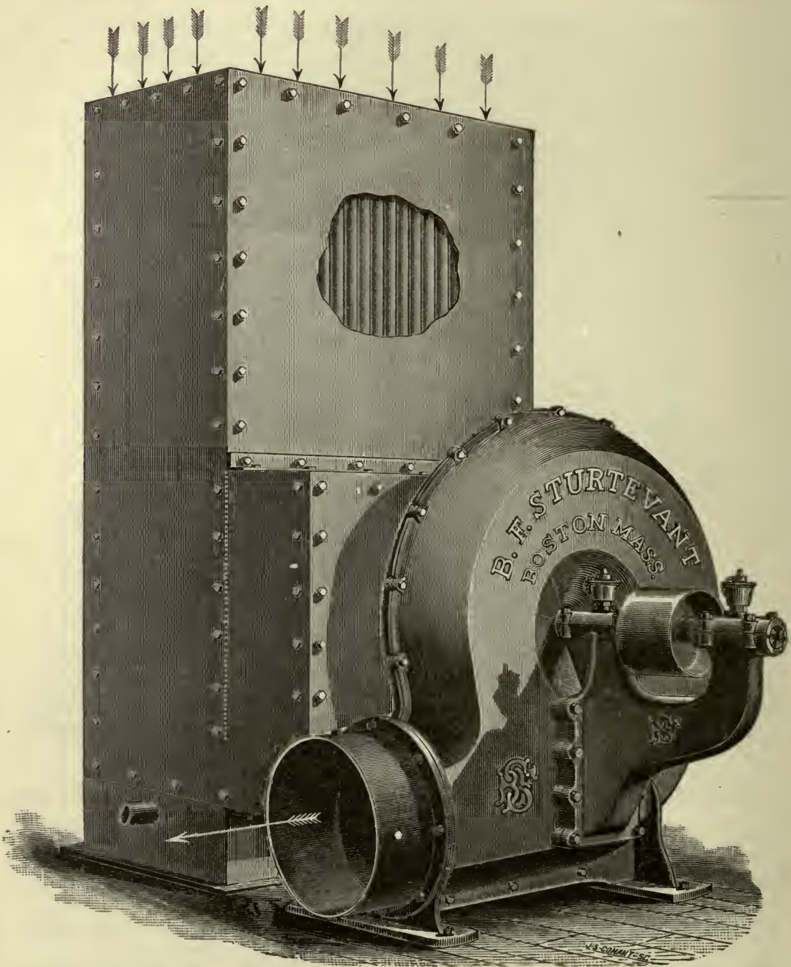


INDIRECT RADIATION.

Base for heater or radiator shown in the preceding illustration. A. Inlet pipe. B. Drip pipe. C. Inlet pipe to a small section for use of fan exhaust where fan ventilation is used. D. Drip pipe for same. E. Ball-bearing, to allow expansion and contraction of base.

heating and ventilation, but subsequent investigation has disproved the assumption. The system is conducive to draughts and partially mixed and improperly heated currents running direct from point of entrance to point of exit. The method cannot be the ideal, as it does not permit the selection of source.

FIG. 107.

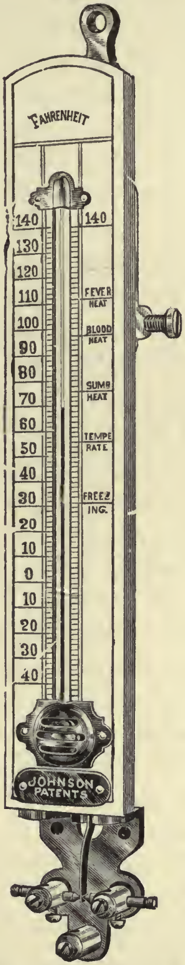


INDIRECT RADIATOR, showing fan attachment for propelling the air from the radiator to the distributing system. The arrows indicate the course taken by the air.

(2d) *The plenum system.* This forces air into the room. The air is heated in winter, or may be cooled in summer, and, by a suitably arranged fan, is forced into the room to be heated, or ventilated, or both. This method not only permits, but demands, the selection of air, and thus meets an important requirement. As the air is brought from a selected point and through specially constructed apparatus, conduits, etc., it may be filtered, dried, or moistened, as occasion demands. The radiator used, or a form used by a firm doing a large amount of this work and constructing nearly all the fans used for the purpose, is shown in the accompanying illustration. By means of a short-circuiting flue, cold air is brought to the fan without passing through the heater; the air thus supplied to the distributing system may be of any desired temperature, the degree being obtained or regulated by a specially constructed mixing damper. The same effect may be obtained, although less effectually, by regulating the supply of steam to the radiator.

Automatic appliances are now made for regulating electrically the temperature of a room. In each room to be heated is placed a contact thermometer, either mercurial, as figured in thermal disinfection, or metallic, by either of which electric currents are made or broken at the desired degree, which may be set at will ; these

Fig. 108.



Thermostat for Regulating by Electricity the Heat Supply.*

The small screw on the right is so arranged that it sets the point of contact at any desired degree. When the apartment reaches the degree the circuit is completed and the heat cut off. The conducting wires are attached to the three screws at the bottom. With a fall of temperature a contact point is made on the opposite side and the heat is readmitted. This process is so nicely regulated that in all ordinary weather with temperatures above the freezing point a constant room heat can be maintained.

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* For electric contact mercurial thermometer, see page 75.

currents, by well-known electro-mechanical appliances, regulate the steam or hot-water supply to the radiator, the air supply, the velocity of the fan, or the mixing damper, and thus control the temperature of the room to within 1° F. of the desired heat.

In forced ventilation and heating, such as described by the use of fans, the air may be brought in through a comparatively small inlet at a high velocity or through a large inlet at a low velocity. At a high velocity it can be more rapidly transmitted from the radiator to the room, and hence less heat is lost by wall absorption and corresponding reduction in the heating power of the incoming air. But the high velocity creates currents, draughts, and disagreeable hot-air fields in the room atmosphere, and raises the floor dust and dirt into the general air of the apartment. These objections have led practical manufacturers and designers of heating appliances to introduce the air overhead or high up on the walls. It is not for us to argue whether apartments can be heated or ventilated after this method, for it has been demonstrated that they can be, but as the products of respiratory and cutaneous activity ascend, the incoming currents, although much diluting contaminating air, beat it directly downward upon those from whom it emanates. Besides all this, which is an apparent scientific objection to overhead introduction of heated air, the inferior extremities, more particularly the feet, cannot be kept warm by this method, in rooms where tile, stone, or metal floors are used, unless the overhead temperature be excessively high. The ideal method of introducing the air into the room is through large washboard registers having a very large outlet or with specially constructed distributors for preventing the induction of currents.

To Estimate Heat Supply. A thermal unit, in heat calculations, is the amount of heat which will be required to raise 50 cubic feet of air through 1° F.

Each square foot of radiating surface from a steam or hot-water radiator will give off from 1.25 to 2 thermal units per hour for each degree difference between the temperature of the radiator and that of the external or surrounding air.

For an indirect radiator this may be computed as 1.75 thermal units, while in direct radiation 1.15 thermal units will accomplish as much as the 1.75 thermal units by indirect. If, however, an equal quantity of fresh air is supplied in the two instances, much less difference will be apparent. To find the radiating surface necessary to heat a given quantity of air, the number of thermal units is first obtained by multiplying the number of cubic feet of air to be heated by the difference between the temperature of the incoming air and the temperature desired, and dividing the result by 50; this will give the number of thermal units demanded.

To determine the amount of radiating surface in square feet for either the direct or indirect radiator it will be necessary to divide the number of thermal units desired by the difference between the temperature of the radiator and the surrounding air. The following somewhat modified example, by Billings, will illustrate what is meant. A room is to have 6000 cubic feet of air per hour to be heated from 0° F. to 70° F. by a direct or indirect steam radiator whose temperature is 210° F.

$$\frac{\begin{array}{c}\text{Cu. ft. of air to be heated}\\ 6000\end{array} \times \left(\begin{array}{c}\text{From } 0^\circ\text{ F. to } 70^\circ\text{ F. or}\\ \text{difference } 70^\circ\text{ F.}\end{array}\right)}{50} = \begin{array}{c}\text{Thermal units}\\ 8400\end{array}$$

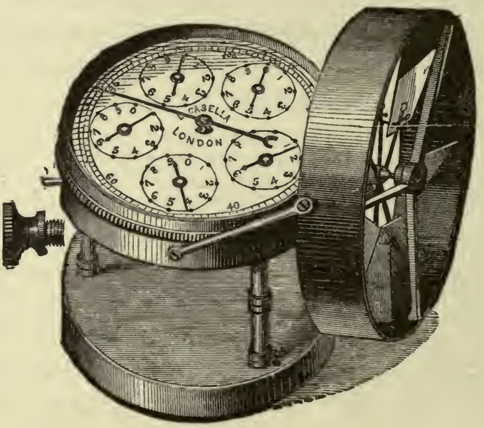
$$\frac{8400}{\left\{\begin{array}{l}\text{Temperature of}\\ \text{radiator minus}\\ \text{temperature of}\\ \text{heated air, or } 210^\circ\\ \text{F.} - 70^\circ\text{ F.} =\\ 140.\end{array}\right\} \times \left\{\begin{array}{l}\text{The thermal unit}\\ \text{value of the radia-}\\ \text{tor to be supplied,}\\ \textit{i.e.,}\text{ 1.75 direct;}\\ \text{1.15 indirect.}\end{array}\right\}} = \left\{\begin{array}{l}\text{No. sq. ft. radiating}\\ \text{surface demanded,}\\ \textit{i.e.,}\text{ 34.3 direct;}\\ \text{52.2 indirect.}\end{array}\right.$$

These formulæ do not take into consideration leakage, wall ventilation, or wall radiation. Wall ventilation and leakage being such unknown factors, it is proposed in the estimates that at most the loss of heat in this way cannot be much and is temporary in outflow, and therefore largely controllable. Radiation from outside walls and windows is not controllable, and is allowed for by adding to the amount of radiating surface obtained by the above method one-half square foot for each square foot of glass or square yard of external wall.

Stoves and furnaces are presumed to produce, for each square foot of heating surface, six times the number of thermal units available from steam or hot-water radiators. Fireplaces or open grates do not permit of calculation estimates, as the heating capacity is entirely dependent upon the temperature of the surface and but little upon the actual consumption of fuel.

It is often desirable to know how much air the ventilating or heating appliances of the room are carrying, and for this purpose an *anemometer* is used. Of these, there are two forms, the *static* and *dynamic*. The former consists of a suspended fan-like obstruction to the flow; the pressure exerted causes this to deviate from the perpendicular, the deviation being registered upon a dial, or arc, attached for the purpose. They really do not give the velocity, but the pressure, and from this the velocity is estimated by experiment or comparison with a dynamic anemometer.

FIG. 109.

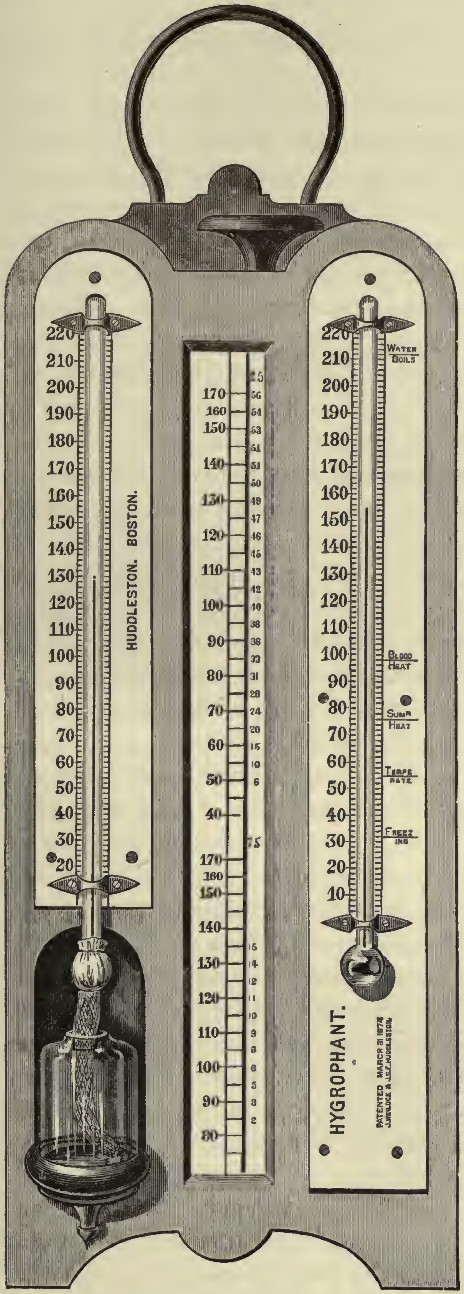


DYNAMIC ANEMOMETER.

On the left is seen the gear catch. The instrument is so placed that the wheel on the right directly faces the current of air to be measured. The turbine-like wheel is allowed to run with the gear catch turned off until its velocity is apparently constant; in the meantime a reading is made of the anemometer and this is recorded; when everything is in readiness, the gear catch is thrown on and the appliance allowed to register for exactly a minute (or any definite length of time), the gear catch turned off, and the dials are again read. The difference between the last two readings is, of course, a record of the intervening time. Corrections for error and friction must be made, and the result is known as final corrected reading.

The *dynamic anemometer* is constructed for the purpose of measuring currents. The accompanying illustration shows the essential features of the modern instrument. A reading is made from several points of the inlet or outlet, other avenues being closed. The velocity being obtained, if we multiply it by the area, we have the amount of air which a room receives, and by knowing the cubic space of the apartment we may know if the air is changing sufficiently often, or if the room is to be occu-

FIG. 110.



HYGROPHANT.

On left, wet-bulb thermometer; on right, dry-bulb thermometer. In the center will be seen two columns of figures, a larger one on the left, and a smaller one on the right; the latter is printed upon a cylinder which can be rotated by means of the milled thumb-screw at the top.

To use the instrument: Read the dry-bulb thermometer, and then the wet-bulb thermometer, and find the difference between the two readings. Then slowly rotate the cylinder by turning the thumb-screw at the top, until the extreme upper figure on the rotating columns is the same as the number of degrees difference between the dry- and moist-bulb thermometers; for convenience, in some of the instruments this row of figures, the top row, is printed red. When the proper figure is in place, look down the left-hand column until the figure corresponding to the temperature, as recorded by the dry-bulb thermometer, is found, when immediately adjoining this, on the movable slip, will be found the relative humidity. For example: As the instrument now stands, the dry bulb reads 155° F., and the wet bulb 130° F., difference 25° F. The rotating cylinder has been turned until the figure 25 comes in view at the top: looking down the columns, we find that opposite 150 in the left-hand column is 53, and opposite 160 is 54, therefore the approximate reading is 53.5 relative humidity.

pied we can calculate the number of people which the given air supply will meet.

The direction of air-flow, where there be currents too weak for ordinary recording instruments, may be indicated by watching smoke generated from tobacco, burning old cotton, velvet, or the slow explosion of a moistened particle of gunpowder, or other devices which may be made to produce a small quantity of heat and considerable smoke. Where obtainable, the "thistle-down" is most delicate in its current reaction. In chimneys, flues, or other appliances of great height, the length of which is known, the velocity of the air traveling through them may be roughly estimated by noting the time which will be occupied by a small puff of powder smoke passing from the base to the top. By knowing the velocity and square sectional area, the amount of air passing through the flue may be readily calculated from the following formula :—

Velocity per second × area in square feet = Quantity per second in cubic feet.

The quantity of moisture in the heated air is a vastly important consideration. The methods available for determining this point are given under climate and air, but a cut of the hygrophant is here inserted, as it is believed to be the most generally applicable instrument. By it but little difficulty will be found in keeping a constant record of the condition of the atmospheric moisture.

Dry airs are moistened by the addition of steam; in steam and hot-water systems this is readily accomplished; in furnaces it may be partly brought about by a water chamber in the radiating box, or wet gauze screens or cloths or sponges are hung in front of the register and moisture thus obtained. The difficulty of this method is the reduction of temperature which occurs from the evaporation of the water. But few other methods are as good and none so simple. Stoves are very constantly supplied with water pans for this use.

LIGHTING.

When the light used is daylight, no matter how circuitous the route by which it is brought to the point of use, the process is spoken of as *natural illumination.*

The best light, the smoothest, most constant, least glaring, is obtained from the reflected rays, rather than the direct rays; such a light, north of the equator, is for the most of the year northern light; south of the torrid zone, the reverse is, of course, the case. As it is necessary to exclude rain and cold, and at the same time admit light, glass is used. The window space of a room should always exceed one-tenth of the floor space, this exclusive of sash and frames. Of the kinds of glass used, common flint or crown plate or stained glass, the plate is to be preferred. It is free from defects, a most important consideration; where direct sunlight is to play upon a window, it is best met by ground glass, *i. e.*, glass in which the polish or glaze is removed from one side. This softens the light, and equalizes it at all points. It is important that the glass be free from all imperfections, such as knots, blisters, and waves, and the glazier directed to have all panes properly back-puttied and bradded, to make them firm and prevent rattling. Leaded glass is not to be advised, as the weird, shadowy lines cast over the room must, of necessity, require an uncalled-for eyestrain.

Since the introduction of stained glass, every conceivable color has been used. The multiplicity of colors used militates against the entire system, and brings it into disrepute when it should be most used.

Leaded glass may be used for the upper lights, and for this, if an ornamental glass is desired, the use of a mild green, and what is known as a sunlight gold, may be recommended for outside ribbon or border lines, with the body in white. This has a charming effect, and will not produce rainbow prismatic lines, which must be more or less injurious to the eyes. White glass, not clear, but cloudy, offers many advantages where large windows are used. It softens the direct rays, and checks the glaring reflections, so commonly the source of annoyance to school-children.

When rooms are lighted by a well, as it is known in architecture, the sides of this structure should be of glazed yellow brick, or polished stone or marble, never opaque dead colors, like red brick or unpolished sand-stone. Sand-stone, more especially the darker colors and softer grains, is so light-absorbing as to make the well which it surrounds dark and gloomy.

The lower rooms of such a well, or along a narrow alley, may have additional light given them by mirrors, or reflectors, hung from the outside, so as to secure reflection of the skylight rays in their direct descent, and through them upon the ceiling of the dark rooms. This method has in a few cases been made to work well, but is of doubtful efficiency, and lessens ventilation, and probably wall radiation.

Artificial Lights. These arise from combustion or incandescence, or both combined. The electric incandescent light offers all that could be desired in artificial light, although, strange to say, it does not support vegetation as does the arc light.*

In stores it has been found that the arc light kept certain of the employees constantly suffering from complementary color images, which so annoyed them as to require a change of light.

Of oil and gas illumination, it may be said that the character of light produced is better from the oil than gas, as ordinarily sold to the consumer. Ventilating gas fixtures are now largely used. A room is lighted by a large central chandelier, immediately over which, or around its supply pipe, a vent is so arranged that the heated air, rising from the burners, is carried off through a ceiling conduit. This not only aids in securing ventilation, but prevents the convection of heat, which, in the summer months, may disagreeably superheat the room. There is no reason for not constructing oil brackets on the same principle.

The air contamination produced by artificial lighting is elsewhere considered, as are also the requirements for satisfactory lighting. (*See page 93.*)

WATER-CLOSET SYSTEMS.

One of the greatest menaces to health is the vitiation of the air in a house by the escape of foul gases through the water-closets. That this danger may be obviated too great a circumspection in the selection of a closet cannot be observed. In the choice of a closet at least three requisites should be demanded: 1st, efficiency; 2d, simplicity; 3d, economy.

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* Recent experiments with lights show that the pigmentation on the dorsal surface of fish can be made to develop on the ventral aspect if the fish be kept in a tank, with the top and sides blackened and arc-light illumination secured from the bottom. No other light would give the same effect.

A closet system to be efficient should be so constructed that no means for the lodgment of excrement in the hopper shall be offered; that the excrement may be readily washed into the soil pipe; that the flush shall be of such volume and force as to thoroughly wash every part of the hopper exposed to contact with the excrement; that the plumbing shall be first-class and all connections carefully effected; that the trap be tight and provided with an antisiphonage and ventilating shaft; and that every facility be afforded for maintaining the cleanliness of the hopper and its surroundings. That rigid simplicity, as far as is compatible with efficiency, should be insisted upon is too palpable to demand discussion, for it must be evident to all that unnecessary complications and "niceties" in closet systems too frequently lead to serious consequences and considerable expense in keeping them in repair.

Within recent years the construction of water-closets has been reduced to a scientific basis, and, as a consequence, the progressive improvements made in this line are little short of the marvelous. There are, however, in old houses, quite a number of what are known as pan closets, valve closets, and long hopper closets.

These closets, having so many grave faults and nothing whatever to commend them, should be considered by all sanitarians and physicians as one of the great evils for which they must ever be on the alert to detect and combat.

It is, probably, expedient that we should point out the defects in the above-mentioned closets, that their merited condemnation shall be just and ample.

Pan closets consist of a hopper, the lower end being closed by a pan containing water. Into this pan the excrements are received, from whence they are projected into the container by raising a lever and dropping the pan.

Beneath the hopper is a large bowl, the container, through which the excrements pass into a D-trap. The D-trap is placed between the container and soil pipe, with the object of preventing an escape of sewer gas into the house.

It may safely be said that the flush in old, unaltered pan closets is never sufficient, and such being the case, feces are sure to be deposited, as instanced in the pan usually becoming encrusted, the lower portion of the hopper and container foul and filthy.

As usually constructed it is almost impossible to ventilate a pan closet or to prevent the siphonage of the traps; hence the escape of foul sewer gas into the house. As the flush is insufficient to thoroughly wash out the container, we have here an accumulation of feces, paper, etc. The gases emanating from a container in such a condition, when added to the escaping sewer gas, render the vitiating air doubly potent and offensive. A D-trap cannot under any circumstances be recommended, but when, as is frequently the case with pan closets, they are made of lead, they become a great source of danger, as the chemical reaction set up between the excrements and the lead ultimately leads to perforation of the trap.

Occasionally it happens that we see a pan closet which is ventilated by carrying a pipe from the container to the vent pipe; further, they are provided with flush tank, which gives an ample supply of water, and the old D-trap replaced by a siphon trap.

In such instances these alterations were only completed years after the pan system had been in operation, and when the inmates of the house had become aware of the truly pernicious character of the system, and were anxious to adopt any plan by which the evil might be mitigated.

Valve Closets. Having, at some length, set forth the objectional features of the pan closet, but little needs to be said in regard to the valve closet, as it is but a modified, though but little improved, form of the pan variety.

In this, the valve variety, a flat iron plate—the valve—supplants the pan; and the the container is somewhat smaller, otherwise they are practically the same.

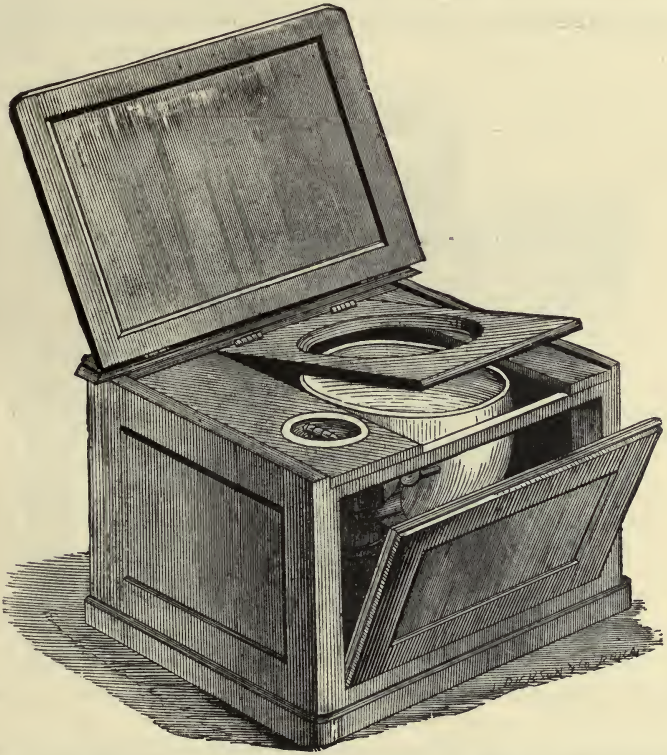
The *long hopper closet* has a long, narrow, conical hopper, opening into an S-trap. As usually constructed, the trap is unprovided with an antisiphonage and ventilating shaft, the flush is inadequate, and the connections are bad. In addition to all this, the excrement adheres to the sides of the hopper, which is almost without exception in a filthy condition.

Enclosed Closets. There is, usually, one great evil associated with all three of the foregoing water-closets, and that is, they are enclosed.

The enclosures surrounding water-closets, more particularly in old houses, are the depositories and conservators of all kinds and manner of dust and dirt. Seldom is it that any arrangements whatever are made to facilitate the cleaning of the enclosed spaces.

When enclosed closets are now placed in dwellings, they are so constructed that they may be cleaned out; as they offer an effectual hiding place for dirt, careless housekeepers, and nearly all hired help, are sure to avail themselves of so convenient a depository. See Fig 111.

FIG. 111.



ENCLOSED WATER-CLOSET, showing the hinged panel in front and the hinged seat, affording facilities for cleaning.

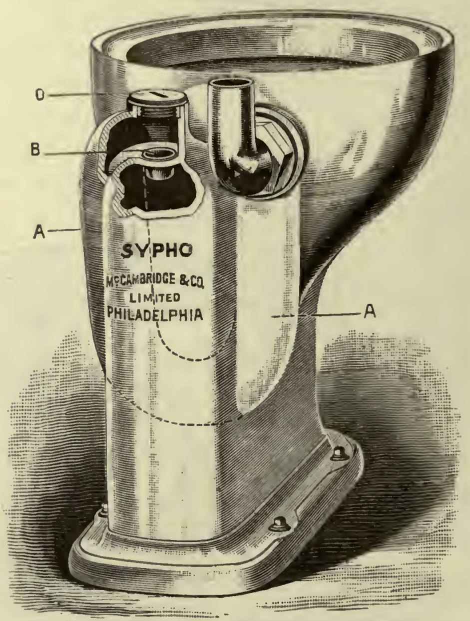
At the present time it is not difficult to obtain a most excellent closet, though to say which make or variety is the best is almost impossible, as the manufacturers have devoted so much time and study in bringing them to perfection.

The "*wash down*" is one that may be used in ordinary houses, where there is a strict limitation to the bill of expenses. It is in form a short hopper, and, being in one piece of earthenware and with an easy bend, permits of easy cleaning, and can be used for an outside as well as inside water-closet.

The "*Dececo*" is best described as having a high ascending arm, which permits of the water standing high in the basin, and thus exposes at all times a good flow of water.

Siphon action is caused by rapid inflow of water from the supply cistern, and by the rapid withdrawal or outflow of water the excreta is quickly removed.

Fig. 112.



Back of "Sypho" Closet, showing coil or trapped supply, A, leading to port, B, in dome of siphon.

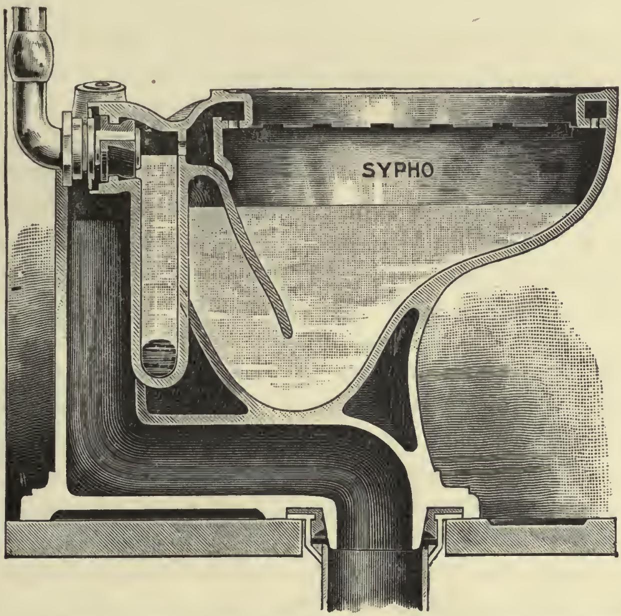
The "*Beekman Salutary System*" consists of a whirlpool closet and "Duplex" tank, and for this it is claimed that the two condients, which extend to the right and left, are so arranged as to spread a fan-like movement of water, which, spreading to the center, forms a whirlpool of great force, which sweeps out the excreta and renders it impossible for any material to be left in the basin. This action is good, and may well be recommended.

The "*Improved Sypho*" water closet is of an improved class, which commends itself from its action and simple operation.

The authors are quite familiar with this closet and highly approve it. The bowl when at rest contains a large volume of water, which forms a trap of such unusual depth as to preclude the possibility of siphonic action breaking the seal. The seal is so perfect as to effectually prevent the passage of sewer gas into the house.

Other advantages of this closet are that it acts promptly, with great force, and is almost noiseless.

FIG. 113.



SECTION OF "SYPHO" CLOSET, showing standing water in bowl, and the opening through which the supply reaches the flushing rim, also coil or trapped supply to long limb of siphon.

In opening the valve in the tank, water flows simultaneously to the bowl and through the coil, A (Fig. 112), to port, B, in the dome of siphon. The water which passed through the port, B, quickly dispels the air from the long limb of the siphon, creating a powerful siphonic action, withdrawing the contents of the bowl, which is driven toward and into the neck or outlet by the force of water from the flushing rim. After the discharge ceases a diminished flow of water from the tank through the flush rim refills the bowl.

The small trapped water-way shown in Fig. 112 will be easily understood by first noting its course; it will be seen to pass from the point where the flush line attaches, down one side of the closet, thence between the limbs, as indicated by the dotted lines to the opposite side, and extending upward, terminates in the port, B, which discharges into the long limb of siphon.

Trough Closet. In large cities with ample water supply and good facilities for handling sewage, trough closets are used in public buildings, schools, manufactories, and other large establishments where many people congregate daily. This form of closet may be considered as a series of washout closets, though it has but a single bowl and flush. The trough, usually of stoneware and without any projection from its interior surface except at the outlet, is placed beneath a series of compartments, each of which has an opening into it. The trough is set in a manner so as to slightly incline toward the outlet, where the floor forms a weir by projecting upward. The object of the weir is to always retain within the trough a quantity of water that will prevent feces adhering to the surface. The upper end of the trough should always be connected with an automatic flush tank of ample capacity. At the lower end of the trough should be placed an iron grid with the bars far enough apart to permit the passage of ordinary matter, yet close enough to intercept all large and improper bodies. The closet should be disconnected from the drain pipe by an S- or siphon-trap. If the closet be within the building, care should be taken to secure a free circulation of air, and with such precautions as to prevent the air passing through this compartment gaining ingress to other portions of the building.

When the closet is enclosed in a special compartment at some little distance from the main building, ventilation may be accomplished by carrying a shaft, with a slight incline, from the trough to outside the building and then directly upward several feet above the roof.

The compartment may be ventilated by a small shaft extending from the highest point within to a couple of feet above the roof.

Urinals.

These are conveniences usually found in railway stations and other large buildings frequented by many people in the course of a day. Nothing ever devised to cater to the factitious demands of civilization has given rise to one-half the nuisance as urinals. However, that such contrivances, from the present condition of society, have come to be a necessity in the business portion of large cities is attested by the frequent uses made of them. Whenever or wherever urinals are to be constructed, great circumspection should be observed in selecting the very best form attainable, and, further, the site selected for them should afford the very best facilities for lighting and ventilation. Urinals should never be situated in dark, damp, out-of-the-way corners. The most essential feature of a good urinal is a copious flush; without this all urinals, whatever may be their merits, are bad and certain to give rise to great nuisance. The best form of flush tank for this purpose is one that acts automatically; and it should be so set that flushes take place every few minutes. Another excellent form, though somewhat more complicated, is set in operation by the person using the urinal standing on a treadle connected by means of a lever with the valve of the tank.

A good urinal will be situated in a well-lighted, well-ventilated compartment with non-porous floor and walls. The urinal will consist of basins, stoneware or porcelain lined, each having a separate waste pipe and well-ventilated siphon trap. The main waste pipe, into which the waste pipes from the basins empty, should not pass directly into the drain, but discharge into a gulley trap.

The slate-back urinals without basins, so frequently met with, are one of the most atrocious offenses against health and decency sanctioned or tolerated by the Health Officers of our day.

To destroy the offensive odors many methods are resorted to, the detail of which space will not permit us to discuss. There is, however, one so simple and efficient as to merit attention: Take a cake of coke or charcoal, saturate it with sulphurous acid, and place it in the basin; the acid should be renewed two or three times each week. Ammoniacal and other odors are thoroughly and quickly destroyed.

Flush Tanks and Cisterns.

With our present system of having special cisterns for supplying the water-closet with a good flush of water, many of the old evils have been eliminated. Nothing could be worse than the sunk dish set in the seat for the pull-up handle, as this permits not only dust and water to collect beneath the seat, but the handle and rod in time become loosened, and, in pulling up, cause the water to be sprayed. The system of the overhead cistern or water tank is now brought down to a basis wherein a regulator for the discharge of two or eight gallons of water can be used in one discharge.

In London and Liverpool the supply is regulated to two gallons to every flush. It is doubtful whether this is sufficient for all ordinary closets. Therefore, whenever possible, it is advisable in setting the cistern to allow of a water flush or flow of not less than three gallons. And this would be all-sufficient to guarantee a properly constructed bowl being freed from excreta.

There are two classes of flush tanks which demand consideration, the *automatic* and *non-automatic.*

Of *automatic flush tanks* we have two varieties, the "tumblers" and the "siphons."

The "tumblers" are tanks varying in capacity according to the requirements. The tanks, scuttle-shaped, are balanced upon pinions projecting from near the center of opposite sides. When empty or during the process of filling they maintain an upright position; but when filled their equilibrium is overcome and they tilt forward, discharging the water. After discharging its contents, the posterior portion of the tank becomes the heavier, and the tank swings back, again resuming the upright position.

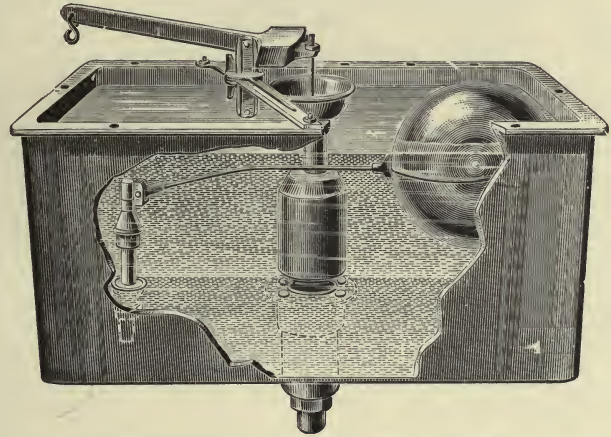
This action continues unceasingly if water be supplied. The rate of discharge can easily be controlled by regulating the inflow.

The mechanism in this form of flush tank is exceedingly simple, is readily controlled, and, in case of break, easily repaired. The authors know of a large manufacturing establishment in which, for the last fifteen years, this system of flushing has been in operation, and it has given the greatest satisfaction.

Automatic siphon traps are in more general use than the above; but that they deserve to be we cannot admit, as they are not so simple in mechanism, so easily controlled, or, in case of breaks, so readily repaired.

One of the simplest forms of this variety consists of a large reservoir, into which the water flows from the main supply. A smaller chamber is situated beneath and at one corner of the large chamber. The two are connected by a hollow cylinder of iron, the long limb of the siphon extending from near the bottom of the smaller chamber to near the top of the larger; this cylinder is surrounded by a metallic jacket, which extends from near the bottom of the large tank to immediately above the upper end of the cylinder. The jacket is closed at the top, thus forming the other limb of the siphon.

Fig. 114.



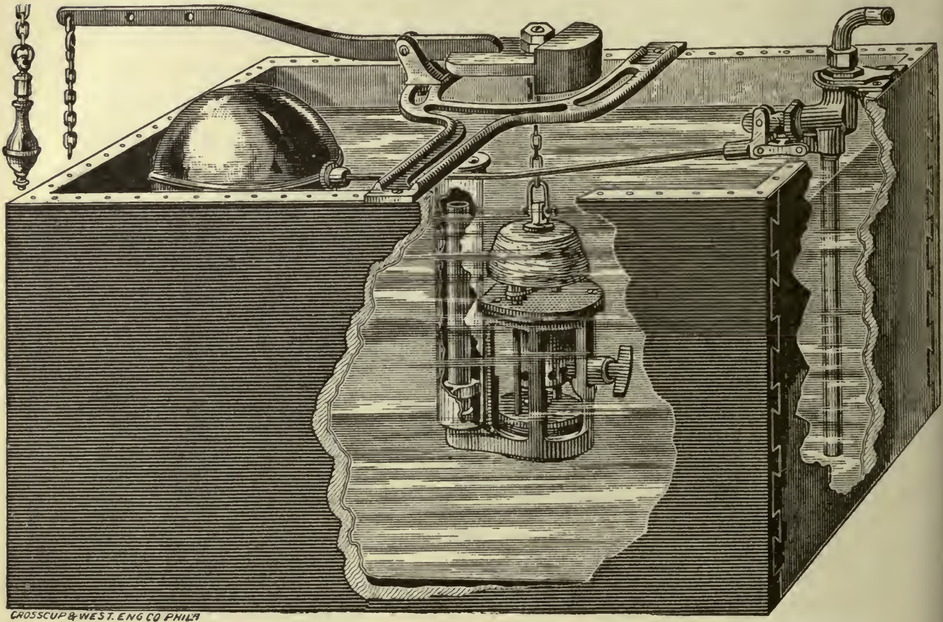
Showing Interior of an Ordinary Flush Tank.

Connected with the middle third of the smaller chamber is the pipe leading to the closet, and up to this point the lower chamber is filled with water. The water in the lower chamber closes the lower extremity of the long limb of the siphon. As the water in the larger chamber overflows into the long limb of the siphon, the water in the smaller chamber flows into the closet pipe, and thus is inaugurated the siphonic action, which, if all things are in good working order, siphons nearly all the water out of the larger tank. The frequency with which this flushing occurs depends upon the rate of the supply.

Other systems more complicated in their mechanism have been devised, but as the simpler ones are equally efficient they are to be preferred.

Non-automatic flush tanks are all constructed upon the lever and valve principle. They consist essentially of a tank of several gallons capacity. The communication between the tank and the flushing pipe is closed by a valve. The short arm of a lever is attached to the valve, while to the long arm, projecting slightly over the edge of the tank, is attached a chain pull. By drawing upon the chain pull the valve is raised and the water rushes from the tank.

Fig. 115.



Interior View of Flush Tank, showing time valve, overflow, supply pipe, and valve connected with floating copper ball, and chain pull and lever.

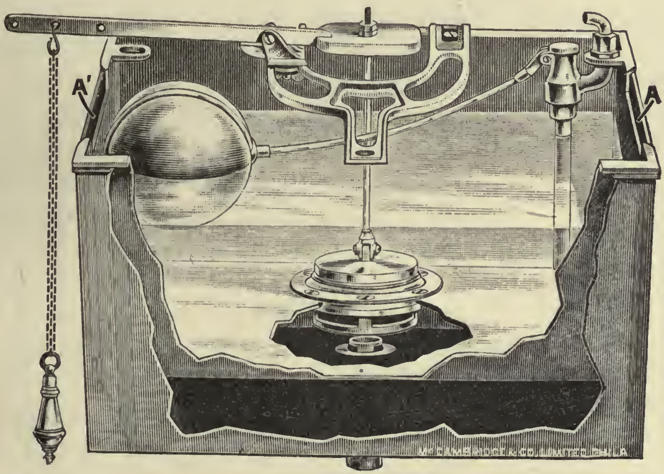
The inflow is controlled by a valve and floating copper ball. As can be seen in the illustration, the copper ball is attached to one extremity of an iron rod, while at the other extremity of the rod connection is made with the valve.

When the tank fills with water the ball floats high, raises the rod, and closes the valve, thus shutting off the water.

Nearly all flushing tanks, by some mechanism peculiar to themselves, provide for an after-flush, just sufficient to fill the bowl of the closet to a proper level.

In many flushing tanks, when the valve is displaced, all the water within flows out; but in others the volume of the flush is regulated by what is known as a time valve, so that any quantity, from one gallon to the entire contents of the tank, may be discharged at will.

FIG. 116.



INTERIOR VIEW OF DOUBLE CHAMBER FLUSH TANK. The space between the two chambers is filled with water by lifting the large valve into the upper chamber, securing a good flush to the closet and a slow afterfill for both trap and pool. A A, simple cutting down of inner chamber to provide for overflow. The inner tank is entirely separate from the outer one, and can easily be lifted out and cleaned.

The time valve shown in Fig. 115 is a simple and very ingenious device, and merits description.

The volume of the discharge is dependent upon the time required for the valve to close after being opened by pulling down upon the chain pull.

The retard action of the valve is accomplished by means ot an inverted chamber, in which is fitted a brass stem with cup leather packing. When the valve is closing water passes into this chamber through a small water-way. The size of the orifice in the water-way is controlled by a small regulating valve. As the valve cannot close until the chamber is refilled with water, then the smaller the orifice in the water-way the longer will be the time required for the chamber to fill and the valve to close. The greater the retardation in the closing of the valve, the greater will be the volume of water discharged from the tank.

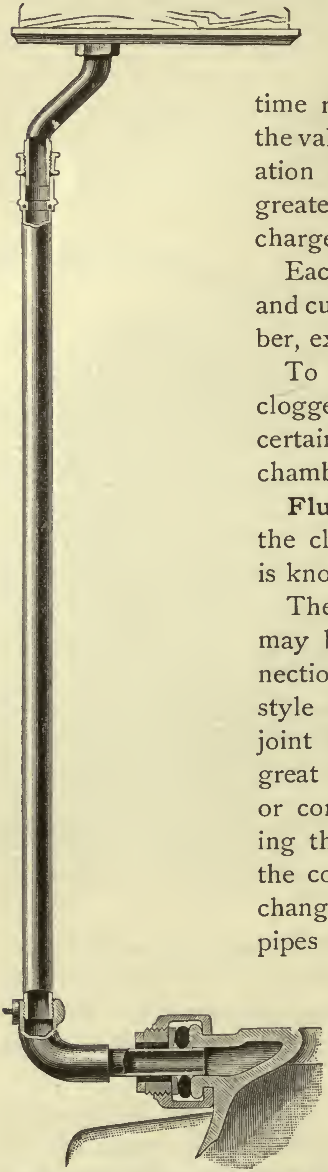
Each time the valve is opened the stem and cup leather is drawn up into the chamber, expelling all water therefrom.

To prevent the water-way becoming clogged, each time the valve is opened a certain quantity of the contents of the chamber is forcibly expelled through it.

Flushing Pipes connect the tank with the closet, and the one in the illustration is known as the "Perfection."

The advantage of this form is that it may be exposed ; it has adjustable connections that it may be adapted to any style closet and cistern, and that the lower joint is flexible, thereby precluding to a great extent the breaking of the bowl or connection, as frequently happens during the settling of the building, or from the contraction and expansion incident to changes in temperature, when the ordinary pipes are used.

FIG. 117.



"PERFECTION" FLUSHING PIPE, showing sectional view of the adjustable connections.

Slop Water for Flushing Purposes. Slop water is often used as a flush for the old hopper closets, and the methods giving the best results are those of Duckett and Allen.

Duckett's Closet. The closet is situated some little distance from the house. The opening in the seat is placed well forward, and the pan connecting it with the trap of the drain inclines slightly backward to prevent the excrement in its passage fouling the surfaces. Interposed between the pan and trap is a chamber having in the floor an annular groove encircling the opening leading into the trap. Into this chamber disembogues the waste pipe from the sink; and the annular groove in the floor always retains a certain quantity of water. The chamber is disconnected from the drain by a siphon trap. The waste pipe from the sink opens into a gully trap situated just without the house; and the gully trap discharges into a tilting vessel or tumbler similar to that described on page 348, but having a capacity of about three and one-half gallons. When the tumbler becomes filled its contents are suddenly ejected into the drain leading to the chamber. And thus we have an automatic flush, the frequency of its action depending upon the volume of the influx; or, in other words, the quantity of waste water thrown into the sink.

Allen's Closet is based upon the same principle as the preceding, but differs in the manner of connecting with the drain or sewer. In this system several closets may be connected with the drain or sewer, though upon each premise there should be a tumbler, so as to provide for an adequate flush. An open-cover manhole with siphon trap should be placed at the entrance of the drain into the sewer. The drains should be ventilated by a four-inch pipe carried above the roof, and ventilation of the closet pans also effected by suitable connections with the vent.

Precaution is taken to place in the closet pans a simple contrivance to prevent the entrance into the drains of improper bodies. The contrivance consists of two converging plates directed downward from either side of the opening in the seat, forming a longitudinal slit two and one-half inches in width, the long axis of the slit being parallel with the antero-posterior diameter of the pan.

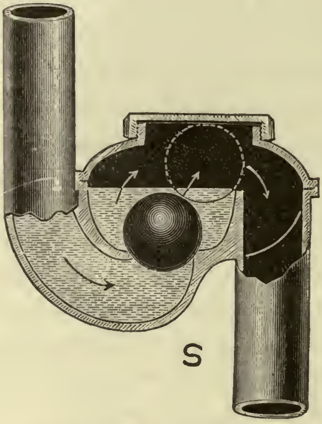
Traps.

Traps are appliances placed between house conveniences and soil pipes and drains or sewers, to prevent sewer gas gaining an entrance into the house.

There are in use at the present time the following varieties: bell traps, gully traps, D-traps, S-traps, Antill's traps, and dip-stone traps, with certain modified and improved types.

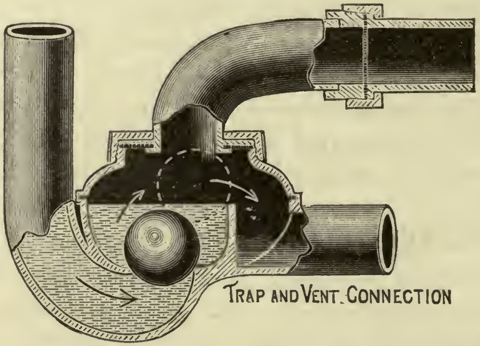
With the exception of the gulley trap and the S-trap, all the above traps are exceedingly objectionable, and in no instance is their use justifiable.

FIG. 118.



SEWER-GAS AND BACK-WATER TRAP, constructed upon the S-principle. The arrows indicate the course of water through the trap; the circular dotted line the position of ball when waste is flowing through the trap.

FIG. 119.



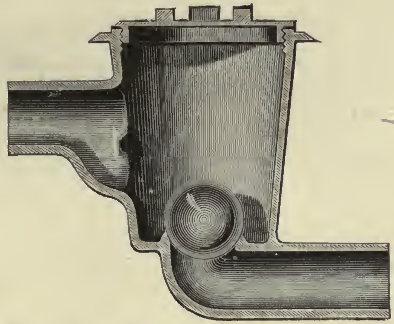
SAME TRAP AS ABOVE, WITH VENT CONNECTION.

Siphon Traps. In ordinary pipes, and in the course of a drain, traps constructed on the siphon principle are the most applicable. The essential requirements of such a trap are: the dip should be of sufficient depth to form an effectual seal; the trap should stand on a flat bottom, that it may the more readily be laid upon a level; that such precaution be taken as to provide for ventilation, prevent siphonage of the trap, and secure ample facilities for cleaning.

Figs. 118 and 119 illustrate an improved form of the S-trap, in which the ordinary water seal is reinforced by a sinking-ball valve. The salient feature of this trap is, that the sinking-ball valve will afford an effectual barrier against the passage of sewer air in the event of the water evaporating.

When water is flowing through the trap, the ball rises against a rubber washer, leaving on either side a large overflow space, twice the size of the inlet pipe. The cover may be readily removed, thus affording easy access to the interior of the trap.

FIG. 120.



SECTIONAL VIEW OF THE BENNOR BATH-TUB TRAP, showing position of ball valve in trap when not in use.

Excepting the dome and cover, which are of hard metal, the trap is made of lead. The ball is made of a non-corroding metal, and, being perfectly smooth, does not accumulate filth. The trap is so constructed that, if desired, the proper connections may be made to secure ventilation.

The gulley trap is the best of that variety constructed upon what is known as the mid-feather principle. In the mid-feather principle the traps have one or more partitions projecting into the water, situated between the entrance and the outlet of the trap. The depth of the seal depends upon the extent to which the partition dips into the water. In this category belong all the above-mentioned traps excepting, of course, the S-trap.

Gulley traps have a distinct field of usefulness, and in this field only are they permissible. This form of trap should be used only in disconnecting the waste-water system and rain pipes from the drain. Gulley traps should never be placed within the house (*e.g.*, in the cellar).

One great objection to the gulley trap is that in warm and dry weather the water seal is apt to be destroyed by evaporation, therefore, precautions should be taken to guard against this contingency.

The trap illustrated in Fig. 120 is styled a "bath-tub" trap, and its efficiency depends upon the security of the sink-ball valve.

The trap is set with its cap on a level with the floor, so that in case of accident it may be reached without difficulty. The cap is usually rough ; but when situated in exposed places it is finished or nickel plated, and made with a wide flange to cover the opening in the floor made for the accommodation of the body of the trap ; thus it does not offer an available place for the deposition of dirt. There are other forms of traps having many most excellent features, but further into this subject space forbids us to enter.

Sinks.

Sinks are generally found in kitchens or other apartments on the first floor, or in the basement, though they may be frequently met with in the upper stories, more especially in large hotels and compartment houses.

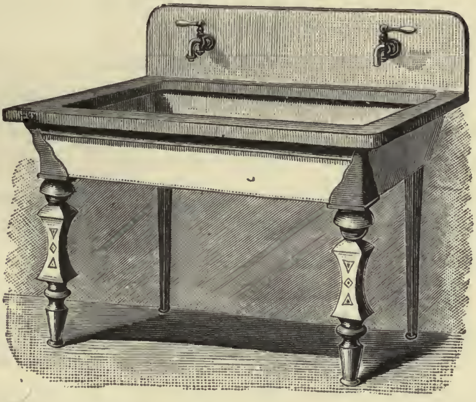
The basin of the sink shown in Fig. 121 is constructed of white crockery, and the top of heavy, well-seasoned ash firmly secured. The sink rests upon galvanized iron legs, affording every facility for maintaining the cleanliness of the free space beneath. The advantages of such a sink are that it is strong, durable, and easily kept clean.

Other sinks lined with lead or tinned copper are greatly fancied by some ; and those of copper are, indeed, excellent sinks, being more durable than those of lead, and presenting a much better appearance.

Sinks should be set in such a manner as to cause the water to flow toward one corner, where is placed the opening into the waste pipe. The opening into the waste pipe should be cupshaped with a grid at the bottom, and fitted with a suitable stopper attached to a chain, that the sink may be made water-tight whenever desired.

The diameter at the juncture of the cup and waste pipe should be one inch greater than that of the latter, to compensate for the space occupied by the grid. That this may be accomplished it is necessary that the waste pipe expand funnel-like as it approaches the point of junction with the sink. The waste pipe should have a siphon trap fixed immediately beneath the grid; and the siphon trap at its lower end a screw cap, that it may be readily kept clean. Continuing on to the side of the house, the waste pipe should open over a gulley or other suitable trap. The siphon and gulley traps disposed as above adduced are indispensably necessary.

FIG. 121.



KITCHEN SINK of white crockery ware, supported by iron legs. Top and wall-board of ash. Position of hot and cold water taps also shown.

Baths and Lavatories.

Baths should never be placed in bed rooms, but in fairly large, well-lighted, well-ventilated compartments especially constructed for the purpose. The compartments, for convenience, may be placed adjoining or near by a bedroom.

For obvious sanitary reasons baths must be efficiently disconnected from the drain by suitable traps, and this is accomplished in the same manner as detailed under sinks.

Ventilation of the pipe is effected and siphonage of the trap prevented by establishing communication between the soil pipe above the entrance of all other waste pipes (See Fig. 123), and at a point in the waste pipe immediately beyond the distal extremity of the trap.

The air pipe, by which communication is established, should be of the same diameter as the waste pipe from which it proceeds. All the baths must be provided with an overflow, connected with the waste pipe on the near side of the trap.

Lavatories demand the observance of the same precautions adduced under baths. Each lavatory basin must have a trap of its own, and each trap properly connected with an air pipe.

Connections.

Pipes. Lead pipes now in use are known as drawn-lead and seamed-lead pipes.

Drawn-lead pipes for water-closet systems are by far the best in use at the present time. They should have a uniform caliber throughout, and weigh, for soil pipes, from seven to eight pounds per superficial foot. For weight per superficial foot for waste pipe see City Regulations.

Seamed-lead pipes are never to be used in sewage systems, as corrosion along the seam is exceedingly likely to ensue; and, furthermore, the expansion and contraction incident to variations in temperature ultimately effects disruption of the seam.

Iron pipes are very unsatisfactory, and for water-closet systems inadmissible, in that it is almost impossible to secure a perfectly smooth interior. They corrode easily, and it is very difficult to make a perfectly tight joint, more especially between them and lead junctions or traps.

Cast-iron pipes are, however, well adapted for the construction of house drains and water mains, and may be employed whenever it is possible to lay them under ground and make proper joints.

Wrought-iron pipes are quickly acted upon by sewage, and it is almost impossible to make the internal surface as smooth as in cast-iron pipes; therefore, heavy cast-iron pipes should always have the preference. For weight per superficial foot see City Regulations.

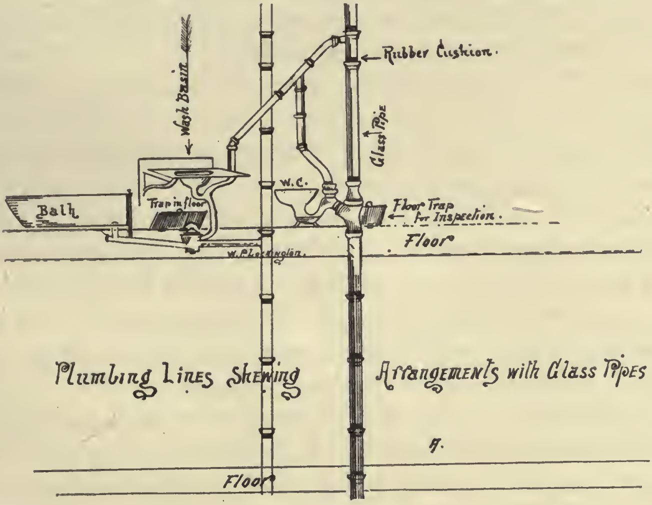
Terra-cotta or Earthenware Pipes. This form of pipe is employed chiefly in the construction of drains and sewers.

Great care must be exercised in selecting the materials, and the party contracting for laying the work must be governed by the City or State Regulations.

Bricks are employed in constructing mains and the larger sewers. Only the very best materials and workmanship should be employed, and all the work should be inspected and thoroughly tested before acceptance.

Glass. While this material involves many excellent features which peculiarly recommend it for the construction of house drains, soil pipes, etc., sanitarians, almost without exception, condemn it on the score of brittleness. It would seem to us, however, that in glass properly prepared the danger of breakage incident to the settling of buildings and variations in temperature would be very small indeed.

FIG. 122.



GLASS PIPE PLUMBING.

In making a test, it has been found that a hollow blown block of glass, hermetically sealed, nine by four inches and two and one-half inches deep, one-sixteenth of an inch thick in center, with moulded lines one-eighth of an inch to receive pressure, would stand a test of two hundred pounds pressure to the foot.

In relation to the theory of substituting the lead pipe by one of glass, we find that drain pipes of glass have already been used, and communications from Pendleton, Ind., prove that they are being turned out in large quantities for shipment out West. In conference with some of our most practical plumbers, while they somewhat doubt the practical use of glass drainage pipes for interior plumbing, yet they do not wholly negative the possibility of its use, and, therefore, this half-expressed doubt, probably born on the cold bed of prejudice, lends some encouragement or hope that in the near future our question of plumbing may be one that will afford satisfaction to the public and prove itself an insuperable barrier against disease.

The *first* objection to be met is the inability of glass pipe to resist the action of extreme heat and cold.

Second. The impossibility to form the necessary joints and elbows.

Third. That the sinking or settling of the foundation will cause the glass pipes to shatter.

In answer to the first, it might be said that glass pipes could be made to stand this test, and, further, that the degree of cold in the house interior is rarely equal to that of the ground.

In answer to the second query: The joints and elbows could be made of various lengths, as in terra-cotta pipes, and the joints could be caulked by teeth edges and cemented.

As to the third objection: Many practical men contend that glass pipes would be shattered through the sinking of a building, but we have yet to find a new building of five stories that has settled five inches. Yet such a case may occur when buildings are erected directly over quicksands, without necessary precautions, and we therefore have to make provision for such extraordinary sinking.

The advantages that should be derived from glass soil pipe are many: *First.* Its glazed surface is stronger and cleaner than earthenware or terra cotta.

Second. The surface is impervious and would, therefore, more readily throw off any foreign matter or substance.

Third. It would admit of an easy inspection by the plumber, professional or layman. On each floor a trap should be left in the form of a flap with hinges, so that in the event of any leakage or stoppage an immediate inspection might be made without tearing up the floor.

Joints. In joining lead pipes three kinds of joints are used, and they are known as the copper-bit joint, the wiped joint, and the blown joint.

The copper-bit joint is far inferior to the wiped joint, but, requiring little of the skill and far less time than is necessary to make the latter, is much affected by contracting plumbers.

Copper-bit joints are made as follows: A pear-shaped block of boxwood, known as a "tan pin," is driven by a mallet into the upper end of the lower segment of pipe, thus making a slight, funnel-shaped rim. The lower extremity of the upper length of pipe is rasped down to fit into the lower segment, and then, by a heated copper bit, stick solder is run into the space between the pipes.

Wiped joints are made by introducing a "tan pin" into one extremity of a pipe in the same way as in making a copper-bit joint, though the flange is not made so large; and the lower extremity of the upper segment is rasped so as to accurately fit into the funnel-shaped expansion of the lower segment without projecting into the interior. A paint composed of lamp-black, glue, and whiting is applied to the contiguous ends of the pipes from two to four inches, depending upon the diameter of the pipe. The surface on either side of the line of junction is carefully shaved, with a tool known as a "shave hook," in such a way as to remove only the paint and the smallest surface of the lead pipe.

Pipes thus carefully prepared present an untarnished surface for contact with the solder, and their thickness is not materially lessened.

To prevent retarnishing in case the solder is not ready for immediate use, the surface is smeared over with tallow. When the solder is ready the surface of the pipes is wiped clean, the solder applied to the untarnished surface, and by means of a moleskin soldering cloth accurately molded to the surface of the pipes.

In making a wiped joint the soldering iron will never be called into requisition except in the instance of vertical four-inch pipes.

The solder for making wiped joints consists of one part of tin to three of lead; while in the making of copper-bit joints the composition is one part of lead and three of tin. The reason for this difference in the composition of the solder is that the one having the greater proportion of tin will the longer retain the heat and permit the solder to enter into the space between the pipes.

Blown joints are made by preparing the pipes as above described, and then heating the abutting ends by means of a blowpipe flame. When the pipes are heated to a sufficient temperature, stick solder is applied; and as it melts it runs into the space between the pipes, and thus the joint is completed. Sanitarians should employ no circumlocution in condemning such joints; they bear no strain whatever, and are only found in the very poorest specimens of plumbing work.

When iron pipes are employed in the construction of soil pipes, they should conform in weight to the list given in the City Regulations soon to be quoted. If of this weight the pipes will permit of the joints being caulked with lead; no other joint should be allowed in such connections.

There are a number of patent joints in the market, and all the more recent ones are of greater or less value; but the scope of this work does not permit of their discussion.

Man-holes.

Man-holes are large trapped chambers placed at the point of junction of several tributary drains with the outfall drain, and in the course of large drains, tributary sewers and mains where they change their course. The foundations of a man-hole should be of concrete; the walls should be constructed of glazed bricks set in cement; and the cover should be a perforated iron grating when the man-hole is so situated as to be free from the danger of being filled with dirt; otherwise it should be covered by an imperforate, accurately fitting door. In the latter instance ventilation is effected by means of a four-inch vent pipe, or by constructing an adjoining chamber which will communicate with the shaft of the man-hole through the upper part of the partition between them. The supplementary chamber should be covered by an iron grating, and below the iron grating should be placed a bucket to catch all dirt passing into the chamber.

As the drains enter the man-hole they empty into grooves or channels in the floor. The grooves are directly continuous with the lumen of the tributary drains. The angle at which side-drains connect with the central channel should be easy, so as not to impede the flow. The central or main channel as it approaches the outlet drain should taper and discharge into a siphon trap of considerably less diameter; thus the main channel from a six-inch drain will discharge into a four-inch siphon trap. The siphon trap, to facilitate cleaning, should be provided with a "raking arm" closed by a tightly fitting cap or plug when not in use.

Drains.

Drains should be laid as nearly straight as possible, with the socket end directed against the flow. The gradient should be uniform and not less than one foot in sixty. Junctions with drains should always be at an acute angle (V-form), and not at a right angle. In V-junctions the sewage enters the main drain in the direction of its flow, thus favoring the flow in the tributary drains. If the junctions are made otherwise than obliquely, more or less resistance to the onflow will be offered, deposition of sewage occur, and finally serious obstructions engendered. Whenever it becomes absolutely necessary to make bends in a drain, it should be done by joining slightly curved pipes, making the bend an easy one, and not by joining straight pipes at obtuse angles.

To obviate the necessity for breaking into a drain to clear away obstructions, inspection pipes are employed. These pipes may be similar to the V-shaped junction pipes, but they are set with the projecting limb directed upward; connected with this projecting limb should be a vertical pipe continuing to the surface above. The pipe should be closed above by an air-tight though easily removed cover.

Sewers.

We have elsewhere considered the materials from which sewers are constructed. Though it is not within our province to discuss the size and fall of sewers, yet so important is it that a few remarks may not be considered irrelevant.

The size of a sewer will, of course, depend upon the amount of sewage it will be called upon to dispose of. But this question we cannot freely discuss; however, the gradient will bear a direct relation to its size. In sewers constructed with an insufficient gradient deposition will surely occur; and to eliminate this factor in obstruction, to render the sewers self-cleaning, and for economy, the capacity should be but little greater than the ordinary every-day demands that will be made upon it. The velocity in sewers should be not less than two and one-half feet per second in those of from one to two feet in diameter, and in sewers of greater diameter at least two feet per second. In the larger sewers the fall will be less, but to attain the desired rate of flow it must be compensated for by the greater volume of sewage. As an example we adduce the following table:—

Diameter.	*Gradient.*
10 feet,	2 feet per mile.
5 "	4 " "
2 "	10 " "
1 foot,	20 " "

Thus to secure a flow at the desired rate a sewer one foot in diameter must have a fall of twenty feet per mile, while a sewer ten feet in diameter has a fall of only two feet per mile; but the volume of sewage passing through the larger sewer is one hundred times greater than the volume passing through the smaller. The greater momentum imparted to the greater volume compensates for the diminution in the grade.

While it frequently happens that sewers are constructed so as to carry off only the sewage, the surface and subsoil water being excluded and carried off by other channels, others are so built as to care for both. The former system is known as the separate and the latter as the combined.

The separate system is undoubtedly best adapted for smaller cities and towns, as the surface and subsoil waters can easily and with more economy be cared for otherwise.

For large cities it is best to construct special water ways or sewers for carrying off the surface or rain water; by this means the soil is rendered dryer and more healthful than when the surface water is permitted to soak into the ground. If conveyed to the sewer the surface water, especially after heavy rains, so greatly augments the demands upon the capacity of the sewer, that washouts and breaks are of frequent occurrence. Furthermore, to construct a sewer sufficiently large to meet any contingency, would so increase the extent of the internal surface and resistance to the onflow of the sewage, that deposition could not possibly be avoided. Sewers as now constructed are elliptical; this increases the depth of the flow and lessens the friction.

In the following extracts from the Regulations of the Board of Health of Philadelphia governing the construction of sewage systems will be found directions and specifications, which, when taken in connection with what has already been adduced, will prove amply sufficient for a work of this kind.

"Outside of buildings, where the soil is of sufficient solidity for a proper foundation, cylindrical terra-cotta pipes, of the best quality, free from flaws, splits, or cracks, perfectly burned, and well glazed over the entire inner and outer surfaces may be used, laid on a smooth bottom, with a special groove cut in the bottom of trench for each hub (in order to give the pipe a solid bearing on its entire length), and the soil well rammed on each side of the pipe. The spigot and hub ends shall be concentric.

"The space between the hub and pipe shall be thoroughly filled with the best cement mortar, made of equal parts of the best American natural cement and bar sand thoroughly mixed dry, and water enough afterward added to give it proper consistence. The cement must be mixed in small quantities at a time, and used as soon as made. The joints must be carefully wiped and pointed, and all mortar that may be left inside thoroughly cleaned out and the pipe left clean and smooth throughout, for which purpose a swab shall be used.

"No tempered-up cement shall be used. A straight-edge shall be used, and the different sections shall be laid in perfect line on the bottom and sides; but in no case shall terra-cotta pipes be permitted within five (5) feet of any foundation wall, or for extensions to connect with rain-water conductors, surface, or air inlets.

"*Note.* After the test has been approved by the inspector, iron drain or soil pipes may be tar-coated. But in no case shall any coating be applied to cast-iron soil or drain pipes until test has been applied and approved by the inspector.

"*Rule 11.* The house drain shall not be less than four (4) inches, nor more than ten (10) inches in diameter, and the fall shall not be less than one-half (½) an inch to the foot, unless by special permission of the Board of Health; it shall be laid in a trench cut at a uniform grade, or it may be constructed along the foundation walls above the cellar floor, resting on nine (9) inch brick piers laid in cement mortar (said piers to be not more than seven (7) feet apart), and securely fastened to said walls; no test shall be made by the inspector until said pipes are secured as above described.

"*Rule 12.* The arrangement of soil and waste pipes shall be as direct as possible. All changes in direction on horizontal pipes shall be made with Y-branches, one-sixteenth ($\frac{1}{16}$), or one-eighth (⅛) bends.

"*Rule 13.* The house drain shall be provided with a horizontal trap placed immediately inside the cellar wall nearest to the sewer, or at the curb. The trap shall have a hand-hole, for convenience in cleaning, the cover of which shall be properly fitted and the joints made air-tight.

"*Note.* If the trap on the main drain is placed inside of the cellar wall, there shall be no clean-out between the water seal of the trap and the sewer.

"*Rule 14.* There shall be an inlet for fresh air entering the drain just inside the water seal of the main trap, and also at the rear end of the system when the vertical line of soil pipe is located in the central part of the building and the main fresh air inlet is deemed insufficient to ventilate the entire system. Said inlets shall be at least four (4) inches in diameter, leading to the outer air and opening at any convenient place, with an accessible clean-out. Where air inlets are located off the footway, on grass plats, lawns, etc., they shall extend not less than six (6) nor more than fifteen (15) inches above the surface of the ground, and be protected by a cowl securely fastened with bolts.

"*Rule 15.* Where the drain passes through a new foundation wall, a relieving arch shall be built over it with a two (2) inch clearance on either side.

"*Rule 16.* Every vertical soil pipe shall extend at least two (2) feet above the highest part of the building or contiguous property, and shall be of undiminished size, with the outlet uncovered except with a wire guard. Such soil pipe shall not open near a window nor an air-shaft ventilating living rooms.

"*Rule 17.* Every branch or horizontal line of soil pipe to which a group of two (2) or more water-closets is to be connected, and every branch line of horizontal soil pipe eight (8) feet or more in length, to which a water-closet is to be connected, shall be ventilated, either by extending said soil pipe, undiminished in size, to at least two (2) feet above the highest part of the building or contiguous property, or by extending said soil pipe and connecting it with the main soil pipe above the highest fixture, or by a ventilating pipe connected to the crown of each water-closet trap, not less than two (2) inches in diameter, which shall be increased one-half (½) an inch in diameter for every fifteen (15) feet in length, and connected to a special air pipe, which shall not be less than four (4) inches in diameter, or by connecting said ventilating pipe with the main soil pipe above the highest fixture.

"*Rule 18.* Where a separate line of waste pipes is used, not connected with sewer pipes, it shall also be carried two (2) feet above the highest part of the building or contiguous property, unless otherwise permitted by the Board of Health. But in no case shall a waste pipe connect with a rain-water conductor.

"*Rule 19.* There shall be no traps, caps, or cowls on soil and waste pipes, which will interfere with the system of ventilation.

"*Rule 20.* All soil, waste, anti-siphon pipes, and traps, inside of new buildings, and of the new work in old buildings, and also of the entire system when alterations are made in old buildings, and the owner or agent of said building or buildings shall have contracted to have the entire drainage system tested,—shall have openings stopped, and a test of not less than three (3) pounds atmospheric pressure to the square inch applied.

"*Rule 21.* The drain, soil, and waste pipes, and the traps shall, if practicable, be exposed to view for ready inspection at all times, and for convenience in repairing. When placed within walls or partitions and not exposed to view, or not covered with woodwork fastened with screws so as to be readily removed, or when not easily accessible, extra heavy pipes shall be used at the discretion of the Board of Health.

"*Rule 22.* No drainage work shall be covered or concealed in any way until after it has been examined and approved by a House-drainage Inspector, and notice must be sent to the Board of Health, in writing, when the work is sufficiently advanced for such inspection; and immediately on the completion of the work application must be made for final inspection. The failure on the part of a master plumber to make said application for final inspection, or the violation of any of the rules of the Board of Health in the construction of any drainage work, and failure to correct the fault after notification, will be deemed sufficient cause to place his name on the delinquent list, until he has complied with said rules and regulations. Any attempt on the part of a master plumber to construct or alter a system of drainage during the time his name appears on said delinquent list, will subject him to criminal prosecution.

"*Rule 23.* All drain and anti-siphon pipes of cast-iron shall be sound, free from holes, and of a uniform thickness, and shall conform to the following relative weights:—

Standard.						*Extra Heavy.*					
2	in.	pipe,	4	lbs.	per foot.	2	in.	pipe,	5½	lbs.	per foot.
3	"	"	6	"	"	3	"	"	9½	"	"
4	"	"	9	"	"	4	"	"	13	"	"
5	"	"	12	"	"	5	"	"	17	"	"
6	"	"	15	"	"	6	"	"	20	"	"
7	"	"	20	"	"	7	"	"	27	"	"
8	"	"	25	"	"	8	"	"	33½	"	"
10	"	"	35	"	"	10	"	"	45	"	"
12	"	"	45	"	"	12	"	"	54	"	"

"All drains and anti-siphon cast-iron pipes should have the weight per foot and the name of the manufacturer cast on the exterior surface, directly back of the flange of each section.

"Lead waste pipes may be used for horizontal lines that are two (2) inches or less in diameter, and shall have not less than the following prescribed weights:—

1	inch	pipe,	2	lbs.	0	oz.
1¼	"	"	2	"	8	"
1½	"	"	3	"	8	"
2	"	"	4	"	0	"

"Lead bends or traps for water-closets shall not be less than one-eighth (⅛) of an inch in thickness.

"Waste pipes from wash-basins, sinks, and bath-tubs shall not be less than one and one-quarter (1¼) inches in diameter, and wash-tray waste pipes not less than one and one-half (1½) inches in diameter.

"All joints in cast-iron drain, soil, and waste pipes, should be so caulked with oakum and lead, or with cement made of iron filings and sal-ammoniac, as to make them gas-tight.

"All connections of lead with iron pipe shall be made with a brass ferrule not less than one-eighth (⅛) of an inch in thickness, put in the hub of the iron pipe and caulked in with lead, except in cases of iron water-closet traps or old work, when drilling or tapping is permitted. The lead pipe should be attached to the ferrule by a wiped solder joint.

"All connections of lead pipe shall be by wiped solder joints.

"Every water-closet, sink, basin, wash-tray, bath, and every tub or set of tubs, shall be separately and effectually trapped.

"The trap must be placed as near the fixture as practicable, and all waste pipes be provided with strong metallic strainers. All drains from hydrants shall be trapped, and in a manner accessible for cleaning out.

"Traps of fixtures shall be protected from siphonage. All anti-siphon pipes shall be carried up through the roof or connected with the main soil pipe above the highest fixture.

"Every anti-siphon pipe shall be of lead, of galvanized gas-pipe, or of plain cast-iron pipe. Where these pipes go through the roof they shall extend two (2) feet above the highest part of the building or contiguous property; they may be combined by branching together those which serve several traps. These pipes, where not vertical, must always have a continuous slope to avoid collecting water by condensation.

"All drip or overflow pipes from safes under wash-basins, baths, urinals, water-closets, or other fixtures shall be by a special pipe run to an open sink, outside the house, or some conspicuous point; and in no case shall any such pipe be connected with a soil, drain, or waste pipe.

"No waste pipe from a refrigerator or other receptacle in which provisions are stored shall be connected with any drain, soil, or other waste pipe. Such waste pipes shall be so arranged as to admit of frequent flushings, and shall be as short as possible.

"The overflow pipes from tanks and waste pipes from refrigators shall discharge into an open fixture properly trapped.

"All water-closets within buildings shall be supplied with water from special tanks or cisterns which shall hold not less than eight (8) gallons of water when up to the level of the overflow pipe for each closet supplied, excepting automatic or syphon tanks, which shall hold not less than five (5) gallons of water for each closet supplied. The water in said tanks shall not be used for any other purpose. The flushing pipe of all tanks shall not be less than one and one-quarter (1¼) of an inch in diameter.

"No closet, except those placed in the yard, shall be supplied directly from the supply pipes.

"A group of closets may be supplied from one tank, but water-closets on different floors shall not be flushed from one tank.

"Water-closets, when placed in the yard, shall be so arranged as to be conveniently and adequately flushed, and their water-supply pipes and traps shall be protected from freezing by placing them in a hopper-pit, at least three and one-half (3½) feet below the surface of the ground, the walls of which shall be of brick or stone laid in cement mortar. The waste water from the hopper stop-cock shall be conveyed to the drain through a three-eighths (⅜) inch pipe, properly connected.

"The enclosure of the yard water-closet shall be ventilated by slatted openings, and there shall be a trap door in the floor of sufficient size for access to the hopper pit.

"Water-closets must not be located in the sleeping apartments of any building, nor in any room or apartment which has not direct communication with the external air either by a window or an air-shaft, having an area to the open air of at least four (4) square feet.

"The containers of all water-closets shall be supplied with fresh air, and be properly ventilated, as approved by the Board of Health.

"All water-closets, within a building, using lead connections shall have a cast-brass flange, not less than three-sixteenths ($\frac{3}{16}$) of an inch in thickness (fitted with a pure rubber gasket of sufficient thickness to insure a tight joint), bolted to the closet.

"Where latrines are used for schools they shall be of iron, properly supplied with water, and located in the yard at least twenty (20) feet from the building when practicable.

"Rain-water conductors shall be connected with the house drain or sewer, and be provided with a trap, the seal of which shall be not less than five (5) inches. Said trap shall have a hand-hole for convenience in cleaning, the cover of which shall be made air-tight.

"Rain conductors shall not be connected outside of the main trap, nor used as soil, waste, or vent pipes; nor shall any soil, waste, or air pipe be used as a rain conductor, and, if placed within a building, shall be of cast-iron pipe with leaded joints.

"No steam exhaust or waste from steam pipes shall be connected with any house drain or soil pipe.

"No privy vault or cesspool for sewage shall hereafter be constructed in any part of the city where a sewer is at all accessible.

"No connection from any cesspool or privy well shall be made with any sewer, nor shall any water-closet or house drainage empty into a cesspool or privy well.

"In rural districts waste pipes from buildings may be connected with cesspools constructed for that special purpose, properly flagged or arched over, and not water-tight, by special permission of the Board of Health.

"Privy vaults must be constructed as follows: Each building situate on an unsewered street must have a privy vault not less than four (4) feet in diameter and ten (10) feet deep in the clear, lined with hard brick nine (9) inches in thickness, laid in cement mortar, and proved to be water-tight.

"Privy vaults shall not be located within two (2) feet of party lines, or within twenty (20) feet of a building when practicable; and before any privy vault shall be constructed, application shall be made and a permit for same issued by the Board of Health.

"No opening will be permitted in the drain pipe of any building for the purpose of draining a cellar, unless by special permission by the Board of Health.

"Cellar drains shall be constructed as follows: By a system of French drains, or field tile, to a catch-basin, flagged over; the outlet pipe shall be properly trapped and connected with the house drain, and shall also be provided with a back pressure valve or stop-cock the required size.

"When the drainage of buildings erected prior to 1886 has been inspected and condemned, plans must be filed, and the new work or alterations shall be executed in accordance with these rules and regulations.

"The main drain of every house or building shall be separately and independently connected with a street sewer, where one is provided; and where there is no sewer in the street, and it is necessary to construct a private sewer to connect with one on an adjacent street, such plans may be used as may be approved by the Board of Health; but in no case shall a joint drain be laid in cellars parallel with street or alley. All other drains or soil pipes connected with the main drain, or where the main drain pipe is above the cellar floor, shall be of plain cast-iron pipe, or of wrought-iron pipe with screw joints made with a paste of red lead, and treated to prevent corrosion."

SEWAGE OR WASTE SYSTEM.

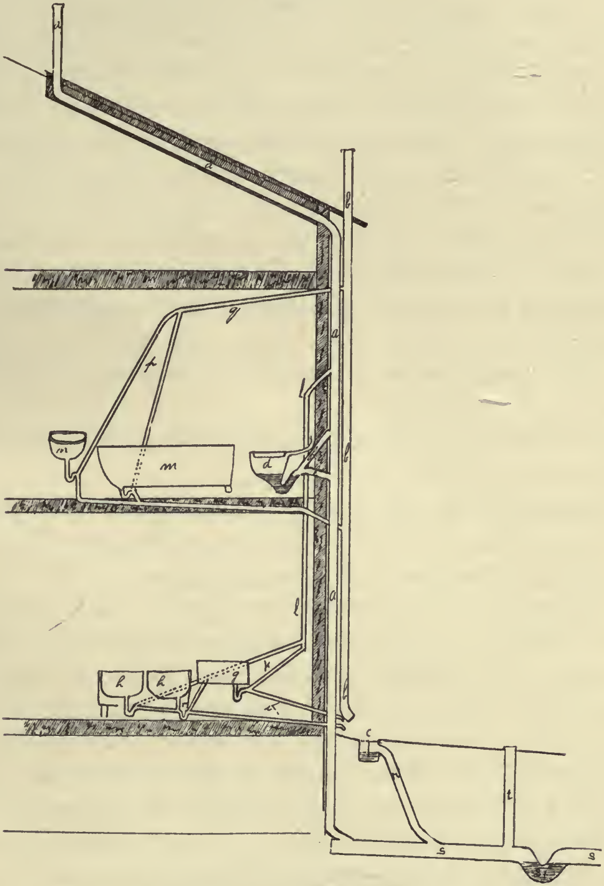
Having considered, at some length, the detail of house plumbing, etc., we shall now proceed to discuss the proper disposition of the appliances. In Fig. 123 we illustrate by diagram the sewage or waste system of a house.

(*a*) Represents the soil pipe abutting against the external surface of the wall (it should never be placed within), and in such a position as not to be exposed to the direct rays of the sun. This latter precaution is taken to preclude the danger of bending, which is almost sure to occur if the pipe is placed in an exposed position. It will be observed, furthermore, that the pipe is carried without any diminution whatever, in diameter, up under the eaves to the highest point of the roof, and from which point it extends directly upward for two feet. The diameter of the pipe should be four inches, as this size seems best adapted to houses of ordinary size. The advantages claimed for this measurement are: that it presents an extent of surface that may be effectually flushed by the volume of water (two to four gallons) discharged from the better forms of flush tanks; that there is less likelihood of deposition than in the larger pipes; and that the suction force is not sufficiently potent to siphon traps with water seals of average effectiveness.

Many architects and sanitary authorities, especially in Great Britain, are advocating the direct connection of soil pipes with drains, though in this country disconnection by suitable traps is still much affected. The former class argue that with the modern improvements in the construction of sewers, tributary sewers, and drains, and by the application of the developed methods for securing ventilation, the sewer gas never attains to a sufficiently high tension to force the traps guarding the water-closets, lavatories, baths, sinks, etc., especially if the soil pipe be constructed in conformity with the specifications just adduced.

b Indicates a special soil pipe into which discharges the waste pipes from the lavatory and bath. It also passes down along the outside of the wall to discharge upon a gully or other suitable trap. This pipe should never connect directly with the drain or sewer. No waste pipes or vents from water closets, urinals, sinks, or laundry tubs are to be connected with this pipe. Soil

FIG. 123.



PLAN OF SEWAGE SYSTEM IN HOUSE.

pipe *b* is not under any circumstances to be connected with soil pipe *a*.

In the construction, soil pipe *b* is to be continued, undiminished in diameter and without any deviation from a straight line, 12 inches above the eaves of the house, it not being necessary in this instance to carry it to the highest point of the roof.

(*c*) A gully trap placed just without the house and over which discharge the waste pipes from the sink and laundry tubs, and the special soil pipe carrying the waste water from the bath and lavatory. The rain water from the roof also enters the drain from this point. The surface of the yard or free space about the house should be so graded that the surface water will flow into the trap.

(*a*) Water-closet, showing the connection of the flush pipe, the position of the trap, the manner in which ventilation is secured, and siphonage prevented by the proper disposition of the vent (*f*).

(*e*) The waste pipe from water-closet, showing its course and connection with soil pipe.

(*g*) Kitchen sink, showing position of the trap and vent (*k*) and the course of the waste pipe (*i*).

(*h*) Laundry tubs with traps, and, as will be seen, both tubs are disconnected by each having its own trap. The vent (*k*) again shows the manner of protecting traps.

(*l*) Represents the common vent pipe of sink and laundry tubs. This vent passes up to a point above where the waste pipe from the closet enters the soil pipe; it then passes through the wall to connect with the soil pipe. This arrangement of the vent is to prevent the waste materials discharged into the soil pipe from upper stories gaining an entrance into it. The waste material discharged into the soil pipe will find an entrance into the sink and laundry tubs if the vents from the latter should enter the soil pipe below the waste pipes.

It can be given as an unalterable rule that vents must always connect with soil pipes above the entrance of all waste pipes.

(*m*) Bath tub, showing the position of trap and connection with the waste pipe (*o*) from the lavatory. The over-flow pipe from bath is not shown, but it should be so constructed as to connect the bath tub, at a point about three inches from the top, with the waste pipe at a point between the trap and bath tub.

(*n*) Lavatory basin, showing trap and waste pipe (*o*). In this, as in the bath tub, the overflow pipe is not shown, but it should connect with the basin and waste pipe in the same manner as does the overflow pipe of the bath tub, though it will not be necessary to have it open into the basin so far below the top.

(*p*) Indicates the course of the vents and principle involved in ventilating the bath and lavatory waste pipes. The vent, as will be seen by referring to the diagram, does not enter the soil pipe *a*, but the special soil pipe *b*, and at a point above the connection of the waste pipe, which also enters this special soil pipe.

It will be observed that the sink, laundry tubs, lavatory, bath and water-closets are all unenclosed, and in all houses of recent building this plan should be carried out to the letter. The conveniences themselves not only present a much better appearance than when enclosed, but it enables the housewife to maintain cleanliness, and in case of accident facilitates the location and repair of the break.

(*r*) Shows the pipe connecting the gully trap with the under drain.

(*s*) The under drain leading to the sewer and interrupted by a siphon trap, or *S*-trap.

(*s′*, *t*) Position of air shaft on the house (*d*) side of trap.

Having considered the system most generally applied in the disposal of sewage, the water-carrier system, there remains something to be said as to the methods which have been devised for the handling of sewage aside from that of the water-carrier system which is now the most extensively used.

Shone's hydro-pneumatic system depends for its efficiency upon a system of ejectors by means of which the sewage is forced along iron conduits by compressed air. While there are many features to commend this system, sanitary engineers have not as yet made the attainment of sufficient atmospheric pressure of such cheapness as to render it available for the purpose intended by the originator. To the practical sanitarian, the obstacles to the general use of this system are at present insurmountable. The difficulty and expense in creating sufficient power, the cost of the plant, air-tight conduits, etc., the annoyance, if not positive danger, which must result from any accident, such as clogging or leakage, preclude the probability of its becoming generally introduced. The system might be of advantage where it is necessary to force the sewage over a distant rise or under a stream, demanding an additional *vis a tergo* to assist means already at hand.

The Conservancy Methods. In the conservancy methods, attempts have been made to avoid the extensive sewage systems demanded for the water-carrier system, and to devise some means applicable to suburban residences, country sites, and small villages and towns. Two methods are available: (1) The midden or privy system; (2) the pail system. Of the midden or privy system very little can be said as to any good feature which it may possess. As usually constructed, it is worse than the cesspool and maintains all the dangers of the latter. The experience, which has been had at Salford, Manchester, Nottingham, and Glasgow, abroad, and in numerous country residences and suburban villages in this country, has proven to the satisfaction of the sanitarians that it is only a means of stowing away dangerous and unsafe material, and that in the large majority of cases it is less safe, more expensive, and unpleasant than any other system making a pretense to sanitary requirements.

Promising very much better and more salutary results, the *pail system* has been comparatively largely used. This demands a specially constructed closet by means of which the excreta falls into pails. The pail may be of wood or metal, galvanized iron being most generally used. The proposition has been made to construct these pails of some material which would be cheap and destructible, so that the pail and its contents can be treated alike—incinerated, if necessary. The pail should be so constructed as to be air-tight when a properly fitted lid is dropped down upon it. If of wood, the pail should be tarred or creosoted or covered with other impermeable material (on its interior). Quite a number of modifications of the pail system have been employed. The system now in use demands two pails, one for the receiving of excreta and the other for ashes and house refuse. In the Goux system there is pressed into the pail some absorbent material, such as hay or straw, shoddy fluff, or any allied compound, moulded by pressure to the interior of the pail.

Into this the excreta may all go, including the urine, the ashes and house refuse being received into another pail, and in some localities the dry household waste and ashes are added to the excreta, the garbage being kept separate.

In Moule's system, a self-acting closet is used, by means of which the requisite quantity of dry earth or ashes is discharged into the pail each time that it is used. In the consideration of the disposal of this material the reader is referred to the chapter on Sewage.

Fire-plugs, Roads, and Gutters.

Fire-plugs should play an all-important part in the cleaning of our streets, gutters, and drains, besides the uses for which they at present stand. And the principle which the authors advocate is:—

First. To have all roads or streets laid slightly elliptic and covered with either asphalt, vitrified brick, or Belgian blocks. The elliptic form naturally throws off the water to the sides, where a gutter or conduit should be formed by a slightly inverted channel of a width of ten to twelve inches, laid with a good concrete bottom of four inches, with a top surface of two inches of the best asphalt, and so laid that from the middle of the square it should fall with a slight down-grade of one in two hundred and fifty toward either end, or corner of the street.

Second. The fire-plug should be placed directly over this elevated point in the middle of the block, and not at the street corner. This would serve its full purpose in case of fire, as all hose carried by our fire department is sufficient in length to traverse the distance between the center of the square, or block, to the street corner in case of fire at the corner.

Again, every morning or night the plug could be turned or opened to its full capacity, and this would flush the gutter, carrying all refuse down the smooth surfaced gutters to the sewer-trap or cesspool located at the street corner.

Third. The sewer-trap receiving this water, instead of being left open, as is now the case, should be screened with a strongly perforated trap front, to prevent unnecessary matter and refuse being swept down into the sewer-trap below.

The catch-pit would not necessarily be so large, as the quantity of sediment being swept down would perforce be less.

The question of the city's ability to give the required supply of water is one we must leave to the local authorities to determine.

Assuming Philadelphia to have 1151 miles of street, and counting eight squares to the mile, we have 9208 squares. Now to flush the gutters it would be necessary to use not less than 200 gallons to the side of each square, or 800 gallons for the four sides of the square, necessitating a supply of not less than seven million three hundred and sixty-six thousand four hundred (7,366,400) gallons *per diem*, while for ordinary consumption the city needs not less than fifty million (50,000,000) gallons.*

With the street cleaning little or nothing can be said except that it would be well to remember that while the city pays every year thousands of dollars for the cleaning of the streets, it again pays double to have the refuse of the drains taken out under separate contracts, or, in other words, paying to have the dirt taken out that has unnecessarily been swept down the sewers from a lack of ordinary precaution, in not having the drain-traps protected.†

The main sewer would act as the conveying line from all houses, and if, as has been stated, the distributing drain should be laid with a slightly down grade of one in forty, there can scarcely be a question of our having any other than good drainage. And the amount of pure water expended in flushing the gutters would not be lost, since it would have double value, first in cooling the streets and cleaning the gutter conduits, but that amount of water would also serve to maintain in our sewers a better atmosphere, and would force the bad drains more quickly through their respective functions to the outlets.‡

Here, again, the question of using glass drain pipes might be discussed, and this promises to be one of the great products of Indiana's progressive vein.

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* Chicago has a capacity of 3,000,000,000 gallons daily, although the average consumption is about 200,000,000 gallons, leaving a good margin for emergencies.

† This is assumed from an article prepared by the author in 1889.

‡ This system has been found to work in a very praiseworthy manner in Berlin, Upper Silesia, and Frankfort. In the summer-time, when the thermometer stands at 95–100° and 103° F., the plugs would be turned on at 3 P. M., thus cooling the parched streets and rendering purer the air of the city. This applies also in part to the system of sewerage in Paris.

SANITARY INSPECTION OF DWELLINGS.

Every doctor should be able to make an intelligent investigation of the sanitary condition of a dwelling. That the investigation may be of value it must be done systematically. The inspector should make note of the following: 1. *Date of inspection*; 2. *The number and situation of the house*; 3. *Name of the owner*; 4. *Name of the occupant*; 5. *Number of occupants*; 6. *The capacity of the house*; 7. *Free space in front and back of house*; 8. *Condition of yard, alleys, etc.*; 9. *Nature of water-supply*; 10. *Outside drains*; 11. *Cesspools, privies, etc.*; 12. *Nuisances*; 13. *Condition of drainage and spouting*; 14. *Cellar*; 15. *Number of living rooms and their condition*; 16. *Number of sleeping-rooms, their cubic space and condition*; 17. *Closet accommodation and bath rooms*; 18. *Method of ventilation and heating*; 19. *Number and condition of windows*; 20. *Condition of floors and stairways*; 21. *Condition of walls*; 22. *Condition of roof*; 23. *General condition of premises as to repair and cleanliness.*

The free space in front and back of dwellings should always be sufficient to secure good lighting and thorough ventilation. Small, illy ventilated and poorly lighted spaces around dwellings are almost invariably found to be repositories of dirt and all manner of filth. Persons compelled to breathe the befouled air of these spaces suffer with ulcerated sore throat, bronchitis, follicular tonsilitis, follicular stomatitis, diarrhea and dysentery, erysipelas, carbuncles, abcesses; further, these repositories of filth are most conducive to the propagation and spread of tuberculosis, pneumonia, diphtheria, typhus fever, and typhoid fever. From a sanitary point, back-to-back houses are objectionable.

The yards and alleys about the house should be well paved, and the grade of the paving such as to secure the rapid removal of roof and surface water.

The nature of the water supply must always be particularly inquired into. When the water supply is obtained from a well, the construction of the well should first receive due consideration and the inspector should see that it is properly constructed, covered, and ventilated. (See deep and shallow wells.) Attention should then be directed to the proximity of cesspools, middens, privies, manure heaps, stables, and other probable or possible sources of pollution.

If tanks or cisterns are employed for the storing of water, the inspection thereof is first to be directed so as to determine whether the construction and situation are such as are required. It is absolutely essential that the tank or cistern should be water-tight. To test the soundness of such reservoirs, fill them in the evening with water; then cut off all sources of supply and exit and in the morning see if the water has fallen.

There are several potent objections to unsound reservoirs, any one of which would be sufficient to condemn: 1. *Leaky tanks will not hold their full quota of water.* 2. *As the water escapes it saturates everything within reach.* If the reservoir is at the top of the house, the walls and often the ceilings are constantly wet; if under or close to the house, the foundations are always damp. Breaks in the reservoir, by affording a means of ingress to foul air or contaminated water, increase the dangers of pollution. Although it is important that tanks and cisterns be covered and protected, to prevent cats, rats, and other household plagues from sporting or seeking a watery grave therein, it must also be borne in mind that ventilation is equally important. The overflow pipe should never be directly connected with the soil pipe. Direct connection allows sewer gas to escape into the reservoir and into the house, polluting the water and vitiating the air. The pipes leading to the bath and closets should all be disconnected by efficient traps.

Water drawn from public mains has in it dangers peculiarly its own, and the cause is seldom to be found within the house. Leaky pipes, faulty connections, blind extremities to pipes, direct communication with closets, waste water preventers and soil pipes are all to be looked for and when found condemned.

Outside drains, that is drains connecting the house sewage system with the main sewer, should always be trapped before entering the house; they should be ventilated, and tested to determine if any leaks exist. Leaky drains, especially when situated close to wells, are a constant menace to health. Cesspools, deep ash pits, privies, or middens, when placed close to a house or well, taint the air and pollute the water, and thus engender those diseases and depraved conditions of the constitution which attend vitiated air and impure water. Strict attention, therefore, should always be paid to the condition and situation of these (sometimes) necessary nuisances. Sporadic cases of typhoid fever can in many cases be traced to pollution of the water from cesspools, etc., and leaky drains.

Pig-styes, pig wash cisterns, manure heaps, cattle yards, close to dwellings and water supply in rural and suburban districts, and poorly kept courts, filthy streets and gutters in urban districts are nuisances which constantly threaten public health.

The drainage and spouting of dwellings should be equal to any demand that may be made upon them. The spouting for carrying away roof water should be tight, for as it usually runs along an outside wall, any leak will make damp walls, and in addition to ruining the walls will give rise to conditions favoring the development of rheumatism, bronchitis, and other lung affections, including phthisis. In inspecting a drainage or sewage system of a house, the under-drain and all communications therewith should be freely exposed to view. The main drain will usually be found to pass under the cellar. First determine if the drain be badly laid or constructed, and if so, condemn it and advise the construction of a proper one. If the drain be properly laid and constructed, test it as to soundness. To do this stop up the lower end of the drain and fill it with water; then note whether the water falls and the rapidity of the fall. To test whether deposition of a solid matter has occurred, pour in a large quantity of water at a sink or water-closet; then if the water, as it flows from the under-drain, is foul and thick, deposition has occurred and the drain in consequence thereof should be condemned.

To locate breaks in drains first close the ventilating shafts; pour in a few ounces of the oil of peppermint and then some hot water; the odoriferous and volatile principles will be quickly liberated and fill the pipes. The characteristic odor will easily be detected wherever it escapes. A better test may be applied by filling the pipes with smoke from an asphyxiator or smoke rocket, care being taken to close all ventilating shafts and to clean out the traps. The escape of hydrogen sulphid may be detected by passing along close to the pipes strips of paper moistened with a solution of lead acetate. Hydrogen sulphid coming in contact with lead acetate forms the lead sulphid which appears on the strips as a black precipitate. House drains must always be efficiently disconnected from the sewer and ventilated on the house side of the trap. All traps and all subdivisions of the under-drain must be carefully examined. If any cesspools are discovered they must be condemned.

The soil and branch pipes should run along the outside of the house. From the drain and running alongside of the soil pipe there should be a ventilating shaft having a diameter the same as that of the soil pipe and opening above the roof.

Cellars demand a strict investigation. They should have an impermeable floor. The walls and floor should be clean and dry. Cellars should be well lighted and ventilated and all dark corners and grottoes should be closely examined. Deep ash pits are sometimes found in cellars, and when found they should be thoroughly cleaned out and the pit filled to a level with the floor.

The gas plumbing is very important, and leaks, whether due to imperfect connections or breaks in the pipes, are usually detected by the inmates and promptly attended to. The stop-cocks should be so arranged as to allow of their turning but half-way round. This is to prevent persons turning the cock completely around, when, though they put out the light, the gas streams forth at full head.

When inspecting the living rooms, particular attention should be paid to the plumbing. Blind ends to the water pipes are potent factors in endemic and sporadic cases of typhoid fever. In the blind ends of water pipes sedimentation is almost constantly taking place, and when the bacillus typhosus is deposited therein such desirable facilities are afforded for the nourishment and pullulation of the organism that an outbreak of the disease is all but sure to occur.

The waste pipes from sinks should never be connected with the soil pipe, but should discharge outside the house and upon a trapped grating which communicates with the drain. The sink and laundry tubs should be thoroughly flushed with hot water, and in the absence of hot water use cold after the morning's work of house cleaning, and at least twice a week dissolve half a pound of common washing soda in four or five quarts of boiling water and let this run down the sinks; it quickly removes any sediment or accumulation of grease.

The condition of the larder, closets, etc., is to be closely noted, and if the soil pipe passes through them, suitable alteration should be suggested. In sleeping rooms, the lighting, heating, and ventilation are of first importance. A sleeping room should never be heated through another room or hallway. Sleeping rooms should be thoroughly ventilated and windows alone are not sufficient. If no open fireplace or communications with the flue exist, other means must be provided to secure thorough ventilation. It is important that the dimension of rooms, and especially of sleeping rooms, should be accurately measured. The height of a room should be at least ten feet. The cubic space of sleeping rooms and number of people that sleep therein should be determined. Billings gives as the minimum of cubic space to be allotted to each individual the following, which is practically that adopted by many Health Boards :—

In common lodging or tenement house, ...	300 cu. ft.
In school-room, office for clerks, etc., ...	250 " "
In barracks for soldiers or police, ...	600 " "
In an ordinary hospital ward, ...	1000 " "
In a fever, surgical, or obstetric ward, ...	1400 " "

In estimating cubic space height of ceilings above twelve feet is not considered. If there is any danger of overcrowding, the occupants should be warned, that they may make a change in time to escape or to correct the evils attendant upon this condition. Water-closets in sleeping apartments are great evils and should be discountenanced.

The bath-room should not be a musty, illy ventilated or poorly lighted little space under the stairs or in some out-of-the way corner of the house, but a fairly good sized, well lighted and well ventilated room. The water-closet is usually placed in the bath-room and it should abut against the outside wall ; the hopper should be one of recent design, and all pan, long, and short hoppers condemned. The trap should be a good one and provided with an anti-siphonage tube and inspection inlet. The water for the closet should be supplied from a waste water preventer. The waste water preventer should be supplied with water from a system independent or thoroughly disconnected from the general supply system of the house, and return current prevented by a valve. The waste pipes from the bath should not enter the soil pipe, but should discharge with the sink pipe upon an outside trapped grating. Again must the plumbing be carefully examined, and what has already been adduced is here equally applicable.

If there is a heater in the cellar, it should be determined whether it is fed by the soil or external air. Properly constructed heaters are supplied with external air, usually by means of a shaft communicating with the outside. The shaft should be provided with some device to arrest the suspended particles in the air.

Baltimore heaters are in bad repute among sanitarians, for, placed as they are in one of the living or sleeping compartments they heat a second or third compartment by discharging into the latter the heated vitiated air of the former. It occasionally happens that Baltimore heaters have a shaft communicating with the outside air, which supplies them with fresh air. In such instances the objection adduced is not tenable.

Windows should always be arranged that they may be opened and easily removed. The window space of a room should not be less than one-tenth that of the floor space, and every room, however small, should have at least one window opening into the external air.

The walls of dwellings should be constructed, whenever possible, of some incombustible material. There should be a damp-proof course (see Habitations) in each wall. As damp walls are a prolific cause of rheumatism, bronchitis, etc., it devolves upon builders and inspectors to take such precautions as will prevent the penetration of the walls by water. When houses have single outside walls driving wet easily penetrates; the walls, therefore, should be coated with some impermeable material, when such dangers are imminent.

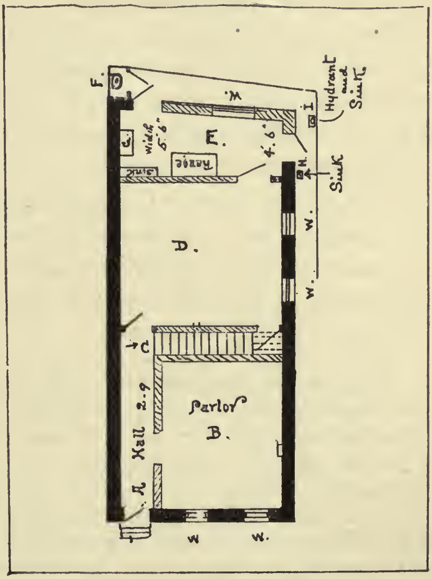
The spaces beneath the lowest story and between the floors and ceilings should be freely ventilated, so as to prevent the accumulation of damp, rank air and the rotting of the joists and flooring. The stairway should be so situated that it may be light and airy and should always be in repair. The space beneath the roof, or, as it is usually called, the attic, should be freely ventilated and kept scrupulously clean. If the water tank or cistern is placed in the attic it is all the more necessary that such precaution should have been taken in the building as will facilitate lighting, ventilation, and cleansing of both tank and attic.

Foul odors are not always indicative of the escape of sewer gas or emanations from near-by wells or cesspools, but frequently attest the presence of decaying animal bodies. As it sometimes happens, rats and cats die in the wells, under the floors, or gain entrance into the drums of heaters, and the horrible odors from their bodies are diffused throughout the house.

In conclusion, note should be made of the general condition of the house. That cleanliness is one of the fundamental laws of hygiene and health, should never be forgotten when inspecting a dwelling. As we pass from cellar to roof, the strictest lookout should be maintained so as to detect any manner of filth.

The flagrant uses of small spaces may be seen by the plans below, made during the inspection of a house on Mount Vernon Street. Here, every known danger is apparent and readily proves the condition of things existing and the builders' ability to pass upon the public that which should be forthwith condemned by the sanitary authorities.

FIG. 124.



UNSANITARY HOUSE, GROUND PLAN.

The house in question is one with a frontage of 15 feet 6 inches and is 38 feet deep. A, represents the hallway which is about 2 feet 6 or 10 inches; on the right, marked B, is the parlor; C, is the box stairway with risers about 7¾ or 8 inches, having not less than 13 steps to the second floor. D, is the dining-room, size about 12 x 9 feet, and opens directly into kitchen, E, with a width of 4 feet 6 inches at the one end and 5 feet 6 inches at the other; in the center will be seen the range, with the cupboard and sink at the side; the kitchen range projects out on the kitchen floor at least 2 feet 3 inches, so that the reader may readily determine how much space there is between this and the window, about 2 feet 5 inches, while at the point marked F, is the water-closet, with lines showing the angle of the kitchen and water-closet doors. H, on the right hand of the kitchen door is a sink which receives the waste water from the bath-room. The letter I designates the hydrant and gully. The outer wall of the kitchen is composed merely of clapboards and tar paper. This needs no comment, but sympathy should be extended to the suffering tenants. In this, vegetables and other things are stored, washing done, food cooked, and this closely upon the water-closet, as will be seen from sketched plan. Indeed, so narrow is the space that as one opens the kitchen door it is thrust at an angle sharply against the water-closet door, and in order to get in the closet, it is necessary to half close the one door before opening the other.

The closet is probably not more than two feet square, with an old fashioned pan, slender-necked; such an arrangement cannot serve for any other purpose than to convey to the kitchen the odor from the excreta and slops, and in turn affect the food and water.

It is impossible to open the back door without admitting a current of foul air into the kitchen, which in turn diffuses with the warm air and is driven through the house.

According to the supplemented act, approved in 1885, the law demands that a space of not less than twelve feet square be left in the rear of the house.*

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* "Every new dwelling house shall also have an open space attached to it in the rear or at the side, equal to at least twelve feet square; and no building of any kind shall be permitted to be erected on any street, court, or alley, hereafter to be laid out, and if laid out and wholly unimproved by brick or stone buildings before the passage of this act, of a less width than twenty-five feet; and every builder or owner who shall hereafter build otherwise than as aforesaid, shall pay to the said city one hundred dollars, to be recovered with costs, as debts of that amount may by law be recovered, and shall also be restrained by injunction from so building; or if having so built after the passage of this act, from the continuance of such building contrary to the requirements of this act, and shall pay all the expenses of such alterations which the court may decree to be made. It shall be the duty of the Commissioners of Highways to give notice to the City Solicitor of all violations of this act."—*Phila. Regulations.*

Again we find the closet of a cheap and inferior kind, incased in woodwork, and an inspection would doubtless bring to light a leakage or an accumulation under the seat of stale urine and rotten boards, fit hiding place for vermin, infectious materials and bad odors. Again, there is an insufficient water flush, and this allows the pan to become browned with the remaining excreta.

Here, too, arises the question of drain pipes; a four-inch pipe would be sufficiently large to carry away the sewage from the house, and in event of a larger one, say, 4½ or 6-inch pipe, being used the question arises as to whether the limited water flow is sufficient flushing power. A danger often arises from this source; the pipe being too large allows of an accumulation in the soil pipe which the inferior or small supply of water is unable to carry away.

The question often arises as to whether the waste pipe from the sink does not communicate with the soil pipe of the closet; if so, this will prove an everlasting source of evil, since the odor will arise and permeate the atmosphere of the kitchen night and day.

CHAPTER X.

SEWAGE.

The term *sewage* as ordinarily used is intended to imply material ordinarily conducted away by means of sewers. These receive the material from the following sources: 1. Surface drainage by means of inlets, usually imperfectly trapped, and carrying the water from the streets and immediate neighborhood of habitations. 2. Waste and used water from household, manufactories, etc. 3. Excreta. As any and all of these may contain elements injurious to health, it is desirous as early as possible to secure their removal as far from the habitation as may be consistent with man's surroundings. As maintained in the chapter on Habitations, it is probable that all surface water and all house refuse water should be treated alike, and the sewage system should be kept separate and distinct. Besides this there must of necessity be accumulated materials which it would be impossible to conduct through sewage. These materials are variously known as garbage, house refuse, by-products, and waste (house); they include solids, waste coming from the kitchen, and very probably such portions of street dirt and refuse as may not find its way into the inlets. Such material is ordinarily known as street dirt.

At one time in Philadelphia and in New York the garbage was used to fill in bulk-heads and embankments, and afterward these became the site of habitations; condemnation of such and similar methods cannot be too strong. Many methods have been devised for handling this class of waste products, but without entering into the discussions which have arisen, there can be no doubt that destruction by heat affords the easiest and safest solution of this difficult problem.

For the *incineration of garbage* quite a number of furnaces have been devised, and several methods have been found eminently successful. Two having been found very useful in England are the Whiley Destructor and Fryer's Incinerating Furnace.

The Engle Cremator has been in successful operation for several years. The difficulty which first arose in construction of crematories of this type, namely the difficulty in securing sufficient draft, has been overcome by increasing the height of the stacks, and in some cases by a forced draft of steam generated through the heat given off during the burning of the garbage.

The Dowling process is now in successful operation in Philadelphia, and from personal observation the writers are inclined to believe that it is eminently successful. The only matter worthy of consideration is the outlay and expense of maintenance. The heat is generated by means of oil forced in through a peculiarly fitted siphon and pressure steam jet. The oil used is ordinary crude oil, a product of but little value. The jets burn directly on and in the garbage, maintaining a temperature which rapidly secures perfect incineration. Before being thrown into the furnace the garbage is pressed through a system of rollers by which it is freed of water, and prior to which solid materials, such as pieces of rock, brick, stone, iron, etc., are picked out. At present, in the city of Philadelphia, no means are at hand for the disinfection of the water which passes off from the garbage. We are promised, however, in the near future, that disinfecting tanks will be constructed for the receiving of the by-product, and in these tanks deodorants and disinfectants will be added in sufficient quantities to insure the destruction of any infectious material, and, possibly, an efficient deodorization. In these incineratories, there is no apparent reason why excreta collected by the pail system should not be incinerated along with the garbage, or, by especially constructed furnaces, be incinerated separately.

The final disposition of sewage is a matter of rapidly increasing sanitary interest. The addition to streams of rapidly increasing quantities of sewage is progressively intensifying the dangers which it should be the object of all sanitarians to abolish. At one time, when it was supposed that water purified itself, the danger of adding to streams the offal from towns had not the recognized importance which the recent advances in the microbic origin of disease has given it. Where we have streams supplying water to a succession of towns situated along their banks, all discharging their sewage into the stream, there is little prospect that the one receiving the last supply of water can escape any infectious disease, which it is supposed can be communicated by water supplied, in consequence of its presence in one of the villages higher up the stream. In other words, the stream has been turned into a sewer in which the sewage receives a more or less definite or irregular dilution.

Not only is this true of streams, but where sewage is being thrown directly into tide-water, and the same is equally true of garbage, the shore soon becomes strewn with materials which otherwise would not have ever presented themselves. This is true not only of towns immediately on the coast where salt water is presumed to exert a certain purifying influence, but inlets and bays in which the tide flows up into the fresh water areas suffer doubly from the reception of sewage. In the first place, the great tendency towards the sea gives rise to the same difficulty to those towns nearer the ocean, and the inflowing tide, no doubt, carries the sewage higher up and discharges it possibly into water inlets above the point of sewage entry. As an example of this, we have the fact that at one time the city of Philadelphia took a certain quantity of its water-supply from what was known as the Kensington Water Works, situated at the extreme northern limit of the city. There was every reason to believe, and few reasons to doubt, that the water taken in by the Kensington Water Works and distributed over certain portions of the city contained infectious materials which had been carried upward by the water current from the streams below, the reflux being due to the tidal flow twice each day. This was demonstrated on one or two occasions when outbreaks of typhoid fever occurred, sharply outlined over the area receiving its water supply from the Delaware and not over the general areas in which the source of the water was the Schuylkill River.

This disturbance of riparian rights and the rapid infection of streams has been gradually acquiring such distinct importance as to lead sanitarians to make an effort to dispose of sewage without discharging it, in its infectious condition, into streams; as a result of this several more or less successful methods have been devised. These practically all amount to one of the four processes: **Sedimentation, Precipitation, Filtration,** and **Disruption.**

Sedimentation. In sedimentation the process devised is dependent for its efficiency upon storage in large tanks for sufficient length of time to allow the suspected matter to subside, when the supernatant fluid is drawn off and the residue treated as will hereafter be described as sludge. This process is too slow and is not available during certain seasons in the year when the high temperature facilitates decomposition, and besides the effluent is never of sufficient purity to be safely freed.

Precipitation. This depends for its efficiency upon the addition of chemical agents to hasten the deposit, which does not take place in the tanks with sufficient rapidity during the process of sedimentation. In order to obtain satisfactory results by the precipitation method the sewage should be delivered as early as possible, before decomposition takes place, into the tanks where it is to receive treatment. After passing through suitable screens to arrest the coarser products, such as babies and other foreign material which may have either purposely or accidentally been cast into the sewage stream, the current should be conducted into tanks not less than 4½ to 6 feet in depth, arranged so that the stream can be readily directed into any one of the series and that precipitation may take place in one of the tanks while another is filling. The materials which have been found most efficient for inducing precipitation are lime, sulphate of iron, sulphate of alumina, sulphuric acid, etc. The best results have been obtained by mixture of more than one chemical. "We think it not inopportune to conclude by mentioning the method adopted in London. The sewage is conducted by the main sewers to Barking and Crossness. Large works have been completed at Barking, and similar works are in process of construction at Crossness, for separating the grosser element. Before the sewage enters the works it is strained through iron cages which retain the larger bodies. This, amounting in one week to seventy tons, is incinerated in a Hoffman Furnace. The liquid, having in suspension the finer particles and a considerable quantity of dissolved organic matter, is directed into large tanks for subsidence, which is facilitated by the addition of lime, thirty-seven grains, and iron sulphate, fourteen grains, to each gallon of sewage. In this manner twenty thousand tons are precipitated in one week. The sludge is forced by powerful pumps into tanks on board ships expressly constructed for the purpose. The ships having a capacity of one thousand tons, convey the sludge to sea, where it is discharged. The effluent, containing but two grains of solids per gallon, disembogues into the Thames.

The abandonment of this process is but a question of time, for it is manifest that such enormous quantities of sludge will eventually so stop up the estuary of the Thames as to seriously interfere with commerce ; and, indeed, may prove a grave source of pollution." (Bevan on "Disposal of Sewage." *Medical News*, January 7, 1893.)

No matter what process may be resorted to, the effluent and the sludge remains more or less infectious in character, and the question of getting rid of this is now a matter of great importance. The sludge may be passed through a hydraulic filter press, depriving it of most of the water, and in this condition it may be used as a fertilizer or possibly be incinerated. It is possible that the same results could be obtained by properly constructed centrifugal machines, and where water power is available, this certainly could be utilized to advantage. The sludge which contains, under ordinary circumstances, over 90 per cent. of water, might possibly be utilized as a fertilizer if mixed with suitable quantities of lime or sand, although the value of this sludge as a fertilizer has been greatly overestimated. The indications are that the sludge must be filtered or deprived of its water, and then incinerated and used as a fertilizer, and that the effluent must be cared for properly to the best advantage by one of the processes of filtration.

Filtration. The ordinary methods of filtration, either downward or upward through sand, gravel, charcoal, magnetic carbide of iron, may be utilized where sufficient land cannot be obtained for handling the sewage by either the process of downward or upward filtration or irrigation. The quantity as given by Wilson is from one-half a million to a million gallons of the effluent per half acre in twenty-four hours. In order to care for this quantity it will be necessary that precipitation, as already directed, shall have been carried on, or that a most thorough system of screening shall be in vogue. The materials removed by the screen had probably best be treated by incineration. The magnetic carbide of iron is presumed to have a purifying influence upon the effluent, and in that manner to lessen the danger from its discharge into the stream. "Of all filtration processes, intermittent downward filtration through earth most completely purifies sewage. The degree of efficiency depends upon (1) the porosity of the soil, (2) the fall of the land. There should be one cubic yard for each eight gallons delivered in twenty-four hours. It is computed that one acre of ground will take up 100,000 gallons of sewage in twenty-four hours. To further facilitate that filtration of sewage, it should be delivered in pipes at least six feet under the surface. The filtration surface should be divided into four sections, and no one section should receive sewage for more than six consecutive hours. The surface of the plot should be plowed in ridges on which vegetables are grown.

"In England, irrigation, combined with either filtration or precipitation, has been pronounced the most efficient and profitable process for the utilization of sewage. The ground selected for the farm should be porous, light, loamy soil. The farms are arranged in ridges along the tops of which run trenches carrying the sewage. The sewage is discharged at regular intervals through a series of sluice-ways into furrows. On the ridges are grown Italian rye, grass, peas, maize, cabbages, cereals, etc. The suspended organic matters are arrested in the soil and oxidized or resolved into harmless compounds by the organisms there present. The dissolved organic substances furnish pabulum for the growing vegetation.

"This country, with its cities environed by extensive agricultural districts, affords most happy and natural facilities for the employment of sewage.

"A modification of the foregoing process might be adopted with profit to a municipality, and the advantages of enriched lands and augmented crops to the agriculturist." (*Bevan.*)

Disruption. It is proposed by the term disruption to consider the method by which the sewage is broken up into the ultimate chemical elements of which it is composed. Of the various processes which have been proposed, the process of electrolysis devised by Mr. Webster, F. C. S., affords some promise, although in the present condition of electrical generation, the expense incident to developing sufficient electricity precludes its general use. It is proposed to secure the breaking up of the sewage by passing it through receptacles containing large flat iron plates to which the poles of a powerful dynamo are attached.

It is said "the chlorids in the water are split up at the positive pole, and the chlorin and oxygen unite to form hydrochlorous acid. This partly attacks the organic matter and also the iron plates, forming ferrous hypochlorite, which, in its turn, is acted on by the bases of ammonia, sodium, potassium, etc., set free at the negative pole, and converted into ferrous hydrated oxid, which becomes the precipitating agent." (*Wilson.*)

CHAPTER XI.

DISPOSAL OF THE DEAD.

Those dead from infectious and contagious diseases should be cared for as already pointed out ("Handling of the Dead from Contagious Diseases," page 80).

What is true of sewage as to the dangers of water supply, applies with more vividness to the disposal of the dead. It is almost impossible to estimate the dangers arising from badly selected and improperly cared for burial sites, and if to these we add improperly constructed graves, we have a complexus of dangers which must appal us. It is not improbable in the writers' minds that with proper disposition of the dead, combined with improved sanitary regulations, a great many of the diseases now rife might be stamped out. The thorough disinfection of all other dangerous materials has been so thoroughly secured by modern scientific advances that with the proper disposition of infected bodies might end all possibility of further spread of the disease from that individual case. Popular education has not yet arrived at that point of advance, where cremation can be universally accepted, but the more rapid the diffusion of scientific knowledge, the more probable the general acceptation of incineration; as the sanitary and scientific destruction of lower animals suffering from disease likely to spread is now demanded, not only by sanitarians but the people in general, why not mankind as well? The efficiency of cremation was early recognized by scientific minds, but sentiment has offered such obstruction as to be not easily overcome. The great tendency toward this method of disposal will be no better illustrated than in the fact that at a recent Congress on Hygiene, it was—

"*Resolved*, that the Government should be urged to remove all legislative obstacles to cremation.

"2. That the Government be urged to adopt cremation of bodies in the battle-field.

"3. That the cremation of the dead is a rational and hygienic procedure, which is especially called for where death occurs from an infectious disease."

The danger which has been advanced of rendering crime more easily hidden by cremation is rather exaggerated, and if all cremations were preceded by an autopsy, it is not likely that any criminals would escape detection through this method of disposal of the dead. Were the vast advantages which must accrue as a result of cremation satisfactorily presented to the public by the scientific professions, progress could most certainly be hastened. The present low cost of incineration renders its early adoption more probable.

Next to incineration, burial is to be recommended. Burial sites should be selected in deference to the surrounding water courses, and care should be taken that no wells or other water courses are in the immediate vicinity or receive the drain from the burial ground. The soil itself should be sandy, preferably not too moist, and should never be located directly over an impermeable strata, as this precludes the possibility of uninterrupted downward filtration. Graves should be deep and facilities should be secured for the easy and effectual disruption of the elements of which the body is composed. Hermetically sealed coffins, imperishable in character, should be discouraged; this is not intended to embrace coffins of wood sealed for the reception or handling of persons dead from contagious and infectious diseases, as these should be of wood and so constructed as to rapidly disintegrate after being placed in the grave. Embalmment should be discouraged, as it greatly prolongs the period in which decomposition is taking place. In Laurel Hill Cemetery the writers have disinterred a body after two years' burial and found it but slightly decomposed, the face recognizable and the garments in a fairly good condition. The coffin should be at least four and one-half feet under ground, the measurement being taken from the top, and where possible superimposed burials should be interdicted. No grave should be opened inside of one year following the interment, and if death was the result of a contagious disease, the period should be certainly doubled, and preferably disinterment prohibited. Receiving vaults, and all temporary or provisional repositories, should be discouraged.

Where for any reason large numbers are to be buried simultaneously or in rapid succession, some method for hastening dissolution should be combined with the ordinary interment. For this purpose a large number of agents have been tried, with more or less satisfactory results. The best recorded results, if one may judge from the large number, was at Metz in 1870. Parkes records the method as follows: "A pit of about seventeen feet in depth was filled with dead, disposed as follows: a row of bodies was laid side by side; above this a second row was placed, with the heads laid against the feet of the first row; the third row was placed across, and the fourth row in the same way, but with the heads to the feet of the former; the fifth row was placed the same as No. 1, and so on. Between each layer of bodies about an inch of lime, in powder, was placed. From ninety to one hundred bodies were thus arranged on a length of six and one-half feet, and reached to about six feet from the surface; the pit was then filled up with earth, and though eight thousand four hundred bodies were put in that pit, there were no perceptible emanations at any time." While here one does not consider the possibility of epidemic death from contagious disease, it is reasonable to infer that the lime would act as an efficient disinfectant. With it might be combined carbolic acid or some similar disinfectant. Chlorid of lime would present all the advantages of lime and the chlorin element add a most efficient disinfecting quality. Strong solutions of sulphate of zinc offer distinct advantages, as would sulphate of iron to a lesser degree. Sulphurous acid should also be useful. As these agents delay decomposition, and thus, in a manner, interfere with a most desirable process, that of decay, they should be used only when infectious elements be present.

CHAPTER XII.

TECHNIC.

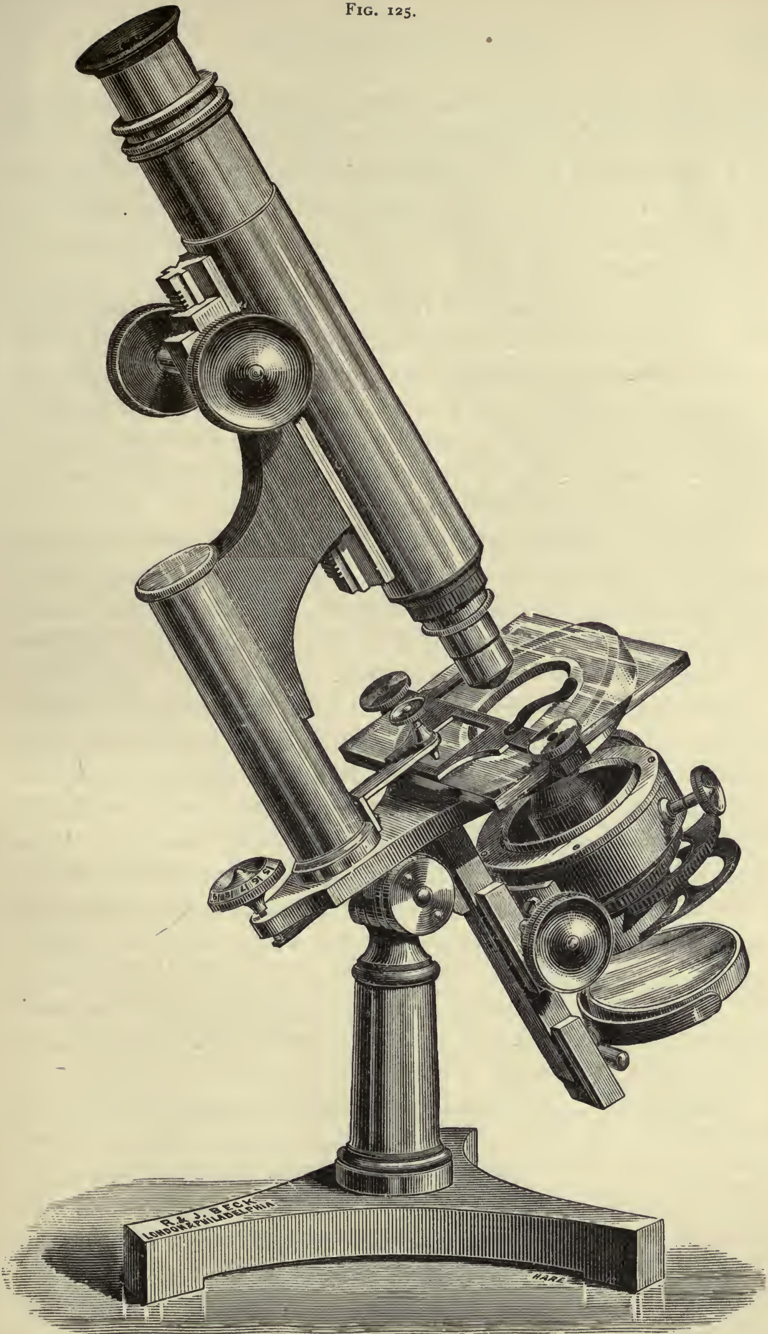
Microscope. In the study of the minute cellular elements, both vegetable and animal, with which it is necessary for us to become familiar, a good microscope and outfit are essential. Beholding the many most admirable instruments which are now upon the market, it becomes an impossible task to say that this or that make is the best. A microscope stand for good all-round work must be the very perfection of art and excellent workmanship. To be deserving of confidence and to aspire to this high distinction it must combine several important qualifications.

The *stand* should have a firm, steady, solid base. The base should be upon the tripod principle, with one foot directed directly backward and the two others directed forward and outward; this arrangement secures the steadiness of the stand, even though the surface of the work-table should not be perfectly level. The body of the stand should be nicely balanced upon an upright rod of the same metal, attached to the base. In many microscope stands the portion of the body above the pinion is heavier than the portion below, and when the upright is of harder metal the wear upon the stand is very great. The harder metal cuts the softer, and this inevitably produces unsteadiness in a comparatively short time. When the body is nicely balanced it may be used in a horizontal position, which quality is in many instances quite advantageous, and in photography absolutely indispensable.

The *coarse adjustment* should be a rack and pinion movement, and the *fine adjustment* should be not only what is claimed for all fine adjustments, but so conveniently placed as not to compel the observer to assume a strained position during its manipulation. All movements should work smoothly and the focusing adjustments should not give any rotary movement to the optical axis of the instrument.

Stage. Provisions should be made for the moving of the

FIG. 125.



BECK'S "PATHOLOGICAL" STAND, showing the tripod base; the nicely balanced body; the rack and pinion coarse adjustment; the position of the fine adjustment; the glass stage working upon metal and held in place by an ivory-tipped thumb-screw; the sub-stage, working by rack and pinion, with condenser fitted in collar and centering screws for adjusting the condenser; the mirror, with plane and concave surfaces.

specimen under examination easily, without jolting or jarring, and so that it at all times may be under complete control. Stages made by a combination of glass and metal parts afford the best means for securing this ease and facility of motion, and while the mechanical stages are desirable, the extra expense is not in proportion to their usefulness.

A *sub-stage*, working by a rack and pinion, should be attached to every microscope, and an arrangement made by which a condenser can be readily adapted to the collar of the sub-stage. The sub-stage should be fitted with a centering arrangement by which the condenser may be accurately centered to the optical axis of the instrument. The mirror of a microscope should have two surfaces, one flat, the other concave.

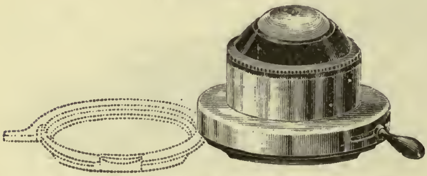
Stands of moderate price which comply with the above requirements are made by Messrs. R. & J. Beck, of London; Bausch & Lomb Optical Company, of Rochester, N. Y., and E. Lietz, of Wetzlar, Germany (branch office in New York City); Carl Zeiss, of Jena, and other reputable makers.

The authors have been using for several years the "Pathological" stand manufactured by R. & J. Beck, and they can attest to its many good qualities. The Bausch & Lomb Optical Co., and Lietz also make stands which in many respects resemble Beck's Pathological, and are in all probability equally as good. Zeiss's stands are in high repute, but in an ordinary outfit the stand is almost entirely destitute of those qualities which make a stand desirable. Accessories are made for Zeiss's stands which, when fitted to it, make it one of the best in the market; but even then so doubtful is the superiority over the stands referred to, that the greater expense of the outfit does not seem to be justified.

Condensers.—Achromatic condensers occupy a high and important place in the pathologist's and micro-biologist's outfit, and a good one should be by all means obtained.

The Abbé condenser, shown in Fig. 126, is a model of considerable merit. The

Fig. 126.



An Abbé Condenser, with Iris Diaphragm.

diaphragm is of the iris pattern and the aperture is readily regulated by the small lever seen projecting to the right from the lower part of the condenser. When in use the condenser should be accurately centered to the optical axis of the objective, and whenever the objectives are changed it will be necessary to readjust the condenser; this more particularly applies to the high powers. To adjust the condenser, close the diaphragm to the smallest possible hole, focus the objective, and move the condenser by the thumb-screws of the centering mechanism, until the rays of light pass through the condenser and objective without deviation. In microscopes not having the centering mechanism on their sub-stages, the advantages conferred by a properly adapted condenser may be decided disadvantages, as the images of objects viewed by the high-power objectives are much distorted by oblique rays of light. Hence many erroneous deductions may be attributed to perverted images, the consequence of oblique illumination and inability to make conformable the rays of light with the optical axis.

Objectives. We now come to the consideration of the most important part of the microscopist's outfit. One may do fairly good work with an inferior stand, with or without a condenser, but good objectives must compensate for other deficiencies. Objectives are made ranging in focal distance from four inches to the one twenty-fifth of an inch; and the greater the focal distance the lower the magnifying power. An outfit will be fairly well-equipped if it contains three objectives having respectively a focal distance of three-fourths inch, one-fourth or one-sixth inch, and one-twelfth inch. The low-power objectives are those ranging in focal length from one inch to one-fifth inch; the medium-power range in focal length from one-fifth inch to one-eighth inch; the high-power range in focal length from the one-tenth inch to the one-twenty-fifth inch. The essential feature of a low-power objective is its penetration and ability to give a perfectly flat field. The objectives of any of the above referred to firms are all excellent and answer this requirement, so we feel no hesitancy in recommending them. Of the medium-powers the one-sixth or one-eighth will be found to be the best adapted for general work. Many of the medium-power objectives have what is known as a correction collar, by which the back combination is made to approximate or recede from the front combination to adapt it to the variations in thickness of cover glasses. Correction collars are unnecessary incumbrances, and we believe that at the present time they are but little used; if they are, those using them seldom bother with this unnecessary refinement. The essential features of a good medium-power objective are flatness of field and definition. Again, we have no hesitancy in recommending the objectives of the firms previously mentioned, and particularly those of Leitz and Bausch & Lomb. The low- and medium-power objectives so far considered are all dry lenses, that is to say, no liquid of any kind is interposed between the lower combination of the objective and the object under examination. Objectives having a focal length of from one-fifth up magnify sufficiently high to enable one to distinctly see the bacillus tuberculosis, and will therefore be of sufficiently high a power to answer the requirements of one who only desires to examine sputum, urine, etc., for diagnostic purposes. The best high-power objectives are what are known as *homogeneous oil immersions.* In these the space between the object under examination and the front lens of the objective is occupied by a specially prepared oil having a refractive index equal to crown glass. The most useful objective of this series is the one-twelfth; angle N. A. 1.25. The high-power dry and water immersion objectives do not give such satisfactory results as the homogeneous oil immersion lenses, and though often answering a purpose, are not to be entirely depended upon. Two essentials of a high-power objective in biologic and sanitary work are penetration and definition, and the objectives of Leitz, Bausch & Lomb, and Beck have given excellent satisfaction in the hands of the authors. Great care must be taken with oil immersion lenses, and, after using, all oil should be carefully wiped off, otherwise the cement between the combinations may soften.

Illumination. Daylight affords the best illumination, but when this fails, resort must be had to artificial illumination. For artificial illumination we use a lamp made by the Messrs Beck, which has certain decided advantages over ordinary lamps. The chimney is of blackened thin sheet iron with oblong openings in front and back, into which fit glass slides 1 x 3 inches. The ordinary microscopic glass slip may be used, or into the back may be placed an enameled glass which acts as a reflector, and into the front a piece of tinted glass. The lamp is attached by a sliding clamp to an upright brass rod, so that it may be set at any height. It is also provided with a movable concavo-convex lens, that the light may be condensed or dissipated to suit convenience.

For ordinary work, however, the common paraffine lamp with a flat wick is all that will be demanded.

Cover glasses are thin plates of white glass cut, usually, either in circles or squares. They are numbered as 00, 0, 1, 2, and 3, according to their thickness, number 00 being the thinnest and number 3 the thickest. Number 1 can be used with most oil immersion objectives and is the best for general work. Cover-glasses may be cleaned with alcohol, slightly acidulated with hydrochloric acid, and fine toilet paper. Hold the cover by the thumb and index finger, between folds of toilet paper moistened with the acidulated alcohol, and, by a gentle motion, rotate the cover with the left hand, care being taken not to allow the thumb or finger to come in contact with the flat surfaces. In the same manner, with a clean, dry piece of toilet paper, wipe the surfaces perfectly clean and dry.

Slides are small slips cut from glass plates one-sixth to one-eighth inch in thickness. The length of the slides is commonly three inches and the width one inch; microscope stages are constructed to accommodate slides of such dimensions. Many qualities of slides are in the market, from the common green glass slide to the highly polished plate glass slide with beveled edges. For every-day work a common white glass slide, free from blubbers or scales, will answer all purposes.

The hollow ground glass slide is made for special work, *e. g.*, hanging drops and drop cultures. This form of slide is of great value to bacteriologists, as it enables them to study microörganisms during life, and in certain experimental work, such as testing the germicidal value of chemical substances, is indispensable.

The selection of jars for preserving specimens and the transportation of water, etc., will often cause considerable bother and annoyance, and when specimens are placed in poor containers they are frequently ruined. The jar shown in Fig. 127 is known as a jelly jar, and is an excellent container for small specimens. These jars are made in sizes of 8 and 12 ounces. The lid has on its upper surface a solid wedge-shaped piece of glass set on edge with the pointed extremity at the margin of the lid and the base extending slightly beyond the center. Upon the upper edge of the wedge directly over the center is a notch. On the opposite side of the jar about an inch below the top are attached plates of glass with shallow depressions, into which fit the extremities of a steel wire spring. With the lid in place and the spring drawn over the wedge and placed in the notch of the wedge it is firmly secured. Interposed between the lid and the jar is a rubber ring. We have used this jar for several years and are greatly pleased with it.

Fig. 127.

Jelly Jar Used for Pathological and Anatomical Specimens and Shipping Water.

Fig. 128 shows section and staining dishes in three sizes. The tops of the dishes and the lids where they come in contact with the jars are ground, and by smearing with vaselin or oil they are made air tight. These dishes will be found very useful, and may be used for a number of purposes.

Bacteriologic Technic. With the promulgation of Pasteur's theory of fermentation the inquiring minds of scientists were directed to the development of methods by which we might acquire a more intimate knowledge of these minute organisms. It soon became patent to the early investigators in bacteriology that methods for the artificial cultivation of microörganisms were urgently demanded, and that but little hope for advancement might be expected until such methods were devised.

The first artificial culture media were various organic liquids, and it was not until 1881 that Koch introduced the solid media in the form of nutrient gelatin.

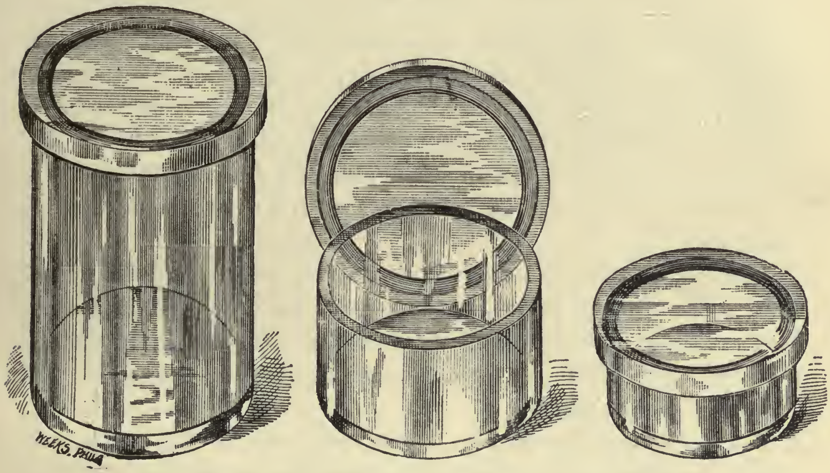
Since 1881 various other solid media have come into use, of which that known as agar-agar, or combinations of agar-agar and gelatin, are probably the most commonly used, in this country at least.

The formulæ for several of the more valuable culture media are appended.

To prepare tubes, flasks, etc., for the reception of nutrient fluids:—

Test-tubes, flasks, etc., are washed, dried, and plugged with absorbent cotton. They are then placed in a dry-air sterilizer or oven at a very high temperature (240° F.), where they remain until the margin of the cotton becomes a light brown. After cooling they are ready to be charged with the culture media.

FIG. 128.



SPECIMEN AND STAIN JARS WITH ACCURATELY FITTING GROUND GLASS TOPS.

Fluid Culture Media.

Cohn's Fluid is prepared as follows:—

Tribasic phosphate of lime,	0.1	part.
Phosphate of potassium,	20	“
Sulphate of magnesia,	10	“
Tartrate of ammonia,	20	“
Distilled water,	100	“

Sterilize thirty minutes for three successive days in steam sterilizer. Do not inoculate until three days have elapsed, after which time they may be used when required, if sterile.

Infusions of horse and cattle manure, hay, etc., are used as culture media, and the same precautions regarding sterilization as previously noted should be observed.

Meat Infusion: Place one pound of finely-chopped beef or mutton, as free as possible from fat, in one liter of distilled water, and stand the container in an ice-chest for twenty-four hours.

Strain through a fine piece of muslin or soft flannel, and add sufficient distilled water to make one liter. Pour into a flask, boil, and filter. Add of peptone (meat or albumin) 10 grams; of sodium chlorid 5 grams. Alkalinize with sodium carbonate, filter, and store in stock-flasks. Another formula is:—

Armour's meat extract,	5 grams.
Peptone,	10 "
Distilled water,	1000 c.c.
Glycerin when desired,	60 grams.

Alkalinize with sodium carbonate, boil, filter, and store in stock-flasks or charge-tubes. 1st day, A. M., sterilize in steam sterilizer for 30 minutes; 1st day, P. M., sterilize in steam sterilizer for 20 minutes; 2d day, sterilize in steam sterilizer for 20 minutes; 3d day, sterilize in steam sterilizer for 20 minutes.

Incubate and keep under observation for one week before using.

Urine and milk are also used as culture media, and the latter forms an excellent pabulum for torulæ, bacilli, and micrococci. It is at all times quite difficult to render milk sterile, requiring thirty minutes each day for six successive days.

Solid Culture Media.

Bread Paste: Thoroughly dry a stale loaf in the oven; remove the crust and reduce the remainder to a fine powder. Then take of these crumbs 10 grams, distilled water 2.5 c.c. Place in a small Bohemian flask and treat as follows: 1st day, sterilize in steam sterilizer (212° F.) for 30 minutes; 2d day, sterilize in steam sterilizer (212° F.) for 20 minutes; 3d day, sterilize in steam sterilizer (212° F.) for 20 minutes.

Keep under observation for at least three days, at the expiration of which time, if they have remained sterile, they are ready for inoculation.

Potatoes: Small or medium-sized potatoes with regular outline and free from "eyes" should be used. Clean the potato, remove the rind, and cut in oblong pieces to fit test tubes.

1st day, sterilize in steam sterilizer for 45 minutes; 2d day, sterilize in steam sterilizer for 30 minutes; 3d day, sterilize in steam sterilizer for 30 minutes.

If no growth has developed by the third day after the completion of sterilization, they may be considered sterile.

Gelatin Nutrient Media: Add 150 grams of gelatin (French "Gold Seal") to one liter of the meat infusion prepared from raw beef or mutton.

It may also be prepared according to the following formula:—

Gelatin,	150 grams.
Armour's meat extract,	5 grams.
Peptones (meat or albumin),	10 grams.
Water,	1000 c. c.

Raise this slowly to a boil, render alkaline with sodium carbonate, filter, pour into stock flasks, and sterilize same as above.

When desired, glucose, 2 grams, may be added to the above.

Gelatin Agar-Agar: This is prepared by adding fifty grams of gelatin and 7.5 grams of agar-agar to the bouillon prepared from beef and mutton or by the following formula:—

Gelatin,	50	grams.
Agar-agar,	7.5	"
Armour's meat extract,	5	"
Peptone (meat or albumin),	10	"
Water,	1000	c. c.

Dissolve the agar in 400 c. c. of the water, then add the other ingredients. Render alkaline, filter, store in stock flasks or charge tubes, and sterilize the same as meat infusion.

Agar-Agar. In the bouillon prepared from raw beef or mutton dissolve 15 grams of agar-agar, or,

Agar-agar,	15	grams.
Peptone (meat or albumin),	10	"
Armour's meat extract,	5	"
Water, distilled,	1000	c. c.

The agar-agar is dissolved in 900 c. c. of water. The solution is facilitated by placing it in a flask for several hours in a steam sterilizer. In the remaining 100 c. c. dissolve the peptone and meat extract, which is then added to the agar-agar solution. The media is rendered alkaline with sodium carbonate, filtered into the stock flasks and sterilized. Two or three eggs may be broken in the media if the filtration does not render it clear, and it is again placed in the sterilizer for thirty minutes; as the albumen of the egg coagulates, it entangles much dirt and helps to clarify the media. After the final filtration sterilize—

1st day for 40 minutes; 2d day for 30 minutes; 3d day for 30 minutes.

When tubes are required they are charged and sterilized in the same manner. If a slanting surface is desired, after the final sterilization they are laid in rows with the plugged ends slightly elevated, and the media can be set at any angle wished. Care should be taken to prevent contact between the media and cotton plugs.

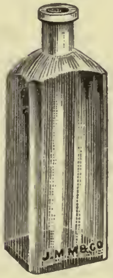
They should be carefully watched for one week after which they may be used if no growths develop.

Plating. Plating is a process by which solid nutrient media are set in a thin layer, that the organisms may develop into colonies and be removed to tubes, etc. The object is to isolate the different bacteria when many varieties are present in the substance to be examined.

Tube plating consists in charging a test-tube with a small amount of nutrient material, and while still in a fluid state, but at a temperature of not more than 105° F., inoculating it with a small quantity of the infected substances. After inoculating the tube plate, it is rotated rapidly on ice; the media sets in a thin uniform layer around the tube. It is then placed in an incubator and should be frequently and carefully examined. As the colonies appear they are removed to tubes. In this climate, in the summer months, gelatin agar-agar or agar-agar is the most suitable media, but in winter gelatin is best if incubation is not necessary.

Another excellent and easy method is the one recommended by Drs. Leffmann and Beam. Bottles ("Blakes" or "Baltimore ovals") are plugged with cotton, sterilized in the hot-air sterilizer, and charged with liquefied culture media (agar or gelatin), and when at a proper temperature inoculated. They are then placed on their sides and the media allowed to set in a thin layer on one or more of the sides and the colonies to develop.

FIG. 129.



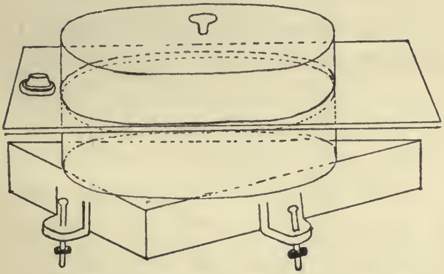
BLAKE BOTTLE USED FOR PLATING.

Koch's Plating Method. Select three tubes charged with nutrient gelatin or gelatin agar-agar, and number them 1, 2, and 3. Liquefy the media and place the tubes in a water bath having a temperature of 110 F. until the media falls to a corresponding degree.

A very small quantity of the material under investigation is by means of an öse introduced into tube No. 1. The media in tube No. 1 is vigorously agitated, so as to secure an equal distribution of the organisms, care being taken not to permit the media to come in contact with the cotton plug. Tube No. 2 is inoculated with a drop of media from tube No. 1 and treated in the same manner. Tube No. 3 is inoculated with one or more drops, as experience dictates, from tube No. 2, and treated as tubes Nos. 1 and 2.

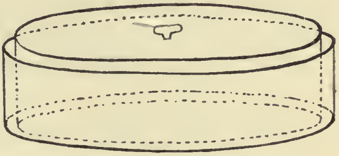
The liquefied media is poured over three sterilized glass plates which are eight to ten centimeters wide by ten to twelve centimeters long; each plate is numbered so as to correspond with the numbers of the tubes from which the media is taken. The plates are immediately placed in an apparatus which has been thoroughly sterilized (Figs. 130, 131). This apparatus secures a perfectly level surface and the media sets in a thin, uniform layer. If it is desired to facilitate the development of the colonies, the large glass dish may be placed in the incubator.

FIG. 130.



KOCH'S PLATING APPARATUS AS ARRANGED FOR "SETTING" AGAR OR GELATIN PLATES.

FIG. 131.



KOCH'S PLATING APPARATUS, MOIST CHAMBER.

A modification of Koch's method is that of Petri.

This investigator employs a dish such as is shown in Fig. 132. The dish is sterilized in a hot-air or steam sterilizer, and the inoculated, liquefied media is poured into the lower dish and the cover replaced. The media is permitted to set, when it may be placed in the incubator if desired. Petri's method does not require the use of leveling apparatus.

FIG. 132.

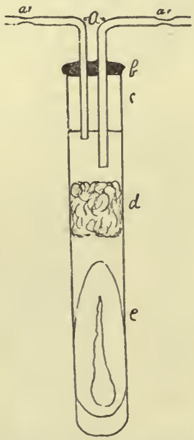
PETRI DISH.

Fractional Plating in Examination of Water. For fractional plating three plates will be required: Plate No. 1 is inoculated with one-half c.c. of the water; plate No. 2 inoculated with one-half c.c. of the fluid from No. 1, and plate No. 3 inoculated with one-half c.c. of the fluid from No. 2. If we have determined by our superficial examination that the water contains but few organisms, 1 c.c. is used for inoculating the plates; whereas, if the sample be teeming with bacteria, one-half c.c. is diluted with a definite quantity of sterile water, and allowance made in numerical calculations if such are to be made.

Agar-agar sets well; it may be incubated; it is perfectly transparent, and liquefaction is exceptional; therefore, we consider it most desirable for plating. When the colonies develop to the size of a pin's head, removals are made to tubes by touching the colonies with a cool platinum wire which has just been sterilized in the flame of a Bunsen burner or spirit lamp, and then stroking the surface of the media contained in the tube.

Counting Colonies. The counting of colonies is easily accomplished by ruling a slate or piece of paper into a number of small squares, then placing the plate over the ruled surface and counting the number of colonies in each square. By adding the number thus obtained the whole number of colonies on the plate is determined.

Fig. 133.



Sternberg's Anaërobic Culture Tube.

a Glass tubing; *a′*, constrictions where the tubes are sealed; *b*, cement; *c*, soft rubber stopper; *d*, cotton plug; *e*, culture media showing growth.

Cultivation of Anaërobes. A number of microörganisms, known as anaërobes, will not grow in the presence of free oxygen, and to cultivate them we have recourse to a special method. To this end hydrogen tubes are most in vogue. The principle involved in this method is the displacement of the air in tubes by hydrogen. The device recommended by Sternberg is of exceeding simplicity, and as the results obtained are satisfactory, it may be accounted as one of the best. This method is illustrated in Fig. 133. Through long tube *a*, which is connected by rubber tubing with a hydrogen generator, passes the hydrogen to displace the air in the test-tube. As the hydrogen enters, the air is forced through short tube *a*. When the air is completely displaced, the hydrogen, if a lighted match be applied to the end of the short tube, will burn with a small flame; but if only a small quantity of air remains when the match is applied, an explosion, which often results in the destruction of the test-tube, will occur. When it has been determined that hydrogen only is passing through the escape tube, both tubes are sealed at the constrictions *a′ a′* by heating in the flame of a Bunsen burner. If the tube contains well set agar-agar and but very little water of condensation, the displacement of air will be hastened by inverting the test-tube. As space will not permit of a detailed description of the many methods that are now employed, we refer the reader to works on Bacteriologic Technic.

Staining.

Histologic Stains. A few stains will be necessary, and only the simplest and most efficient will be enumerated.

Hematoxylin, Alum,	āā 2 parts.
Alcohol, Distilled water, Glycerin,	āā 100 parts.

This solution does not attain full strength until about the eighth day. Sections are stained in equal parts of the dye and water for about one minute, some sections requiring a little more, and others a little less time; remove, wash in water, 60 per cent. alcohol, and thoroughly dehydrate in absolute alcohol, clear in oil of cloves, creosote, or cedar oil, and mount in balsam

Carmin.

Saturated solution of lithium carbonate,	100 parts.
Carmin,	2.5 "

This solution is almost immediately ready for use. Equal parts of the stain and water are employed. The sections remain in the solution from three to five minutes; they are then bleached in acid alcohol; hydrochloric acid one part; water 30 parts; alcohol 70 parts; rinsed in 60 per cent. alcohol, and dehydrated in absolute alcohol, cleared in oil of cloves, and mounted in balsam.

Ranvier's Picrocarmin Stain. One gram of the best carmin is rubbed up with ten c.c. of distilled water, and three c.c. liquor ammonia, and then added to 200 c.c. of a cold saturated solution of picric acid. Evaporate over a water bath at a low temperature, to 100 c.c.

For use, dilute one part of the stain with two parts of distilled water. The sections are to be exposed to the action of the staining solution for one hour, then washed for one-half hour in water acidulated with a few drops of a saturated aqueous solution of picric acid. Dehydrate the specimen in absolute alcohol, clear and mount.

To Stain for Microörganisms.

Weigert's method consists in placing the sections for from six to eighteen hours in a one per cent. watery solution of any of the basic anilin dyes. By warming the stain in the incubator the process is hastened. If a stronger solution be employed, the staining will be more rapid, but the results will not be so satisfactory. The sections are first washed in a one-half saturated solution of potassium carbonate, next in water, then in 60 per cent. alcohol, and finally dehydrated in absolute alcohol, cleared and mounted. After dehydration the tissue may be stained in the lithium-carmin solution, to which has been added ten or fifteen drops of a saturated aqueous solution of picric acid, followed by rinsing in water and then in 60 per cent. alcohol, each of which contain a few drops of the picric acid solution. The sections are dehydrated in alcohol, cleared and mounted.

Gram's Method. Stain sections from three to ten minutes in anilin methyl violet, gentian violet, or fuchsin, prepared as follows:—

Saturated solution of anilin oil in distilled water (filtered),	100 parts
Gentian violet, methyl violet, or fuchsin, saturated alcoholic solution,	11 parts
Alcohol,	10 parts.

Transfer section to Gram's iodin-iodo-potassic solution—

Iodin,	1 part
Iodid of potassium,	2 parts
Water,	300 parts,

until they become a dark brown, rinse in 60 per cent. alcohol, and then decolorize in absolute alcohol, clear in clove oil, and mount. The process of decolorization is hastened, and the beauty of the section enhanced, by removing from absolute alcohol to clove oil, and, after a short interval of time, returning to alcohol, then finally clearing in clove or cedar oil, and mounting.

Weigert's Modification of Gram's Method. Stain the sections in lithium carmin, decolorize and dehydrate as already directed. Transfer the section to a glass slip, and cover with a few drops of anilin-methyl-violet, freshly prepared. After five to ten minutes pour off the excess of stain and cover specimen with several drops of Gram's iodo-potassic-iodid solution for one minute; this is now poured off, and the specimen dried by lightly pressing upon it a clean folded piece of filter paper. The specimen is decolorized by permitting anilin oil to flow gently over it; as the anilin becomes stained it must be replaced afresh, and the process continued until the color ceases to come away. The section is cleared in xylol. On first adding the xylol, it will become turbid; therefore we must continue to add the xylol until it remains perfectly clear. Allow a few minutes for the xylol to evaporate, and then mount in xylol balsam.

Löffler's Method. The formula for Löffler's stain is:—

Methylene blue (saturated alcoholic solution), ...	30 parts
Caustic potash solution (1 in 10,000), ...	100 parts.

Specimens are stained in this solution, the time varying with the specimen from one-half hour to twelve hours. The specimen should, after staining, be washed in distilled water, immersed in absolute alcohol, cleared up with cedar oil or xylol, and mounted in xylol balsam.

To Stain the Bacillus of Tuberculosis.

Ziehl-Neelsen's Method. The staining solution is made as follows:—

Fuchsin	1 part
Alcohol	10 parts
Dissolve and add aqueous sol. of carbolic acid (5 per cent.)	100 parts.

Stain sections in the above solution from twelve to twenty-four hours. The staining process can be hastened by heating the solution until steam rises, it being necessary to immerse the sections in the heated solution for only one-half hour. Cover-glass preparations can be stained in from five to ten minutes. After staining, wash away the superfluous stain in distilled water, transfer to 90 per cent. alcohol for several seconds, then to a 25 per cent. solution of sulphuric acid for a few seconds. Wash the sections in alcohol, and if they are sufficiently decolorized transfer to a solution consisting of lithium carbonate 1 part, water 9 parts, and thoroughly wash. After-stain with an aqueous solution of methylene blue, clear in cedar or clove oil or xylol, and mount in xylol balsam.

Koch-Ehrlich Method.

Stain :—

Saturated alcoholic sol. of methyl violet, gentian violet or fuchsin,	11 parts
Anilin water,	100 "
Alcohol,	10 "

Specimens are left in this solution for twelve hours, when they are treated with—

(1) Nitric acid solution (HNO_3, 1 part; H_2O 2 parts) for a few seconds.
(2) Wash in sixty per cent. alcohol for a few minutes.
(3) After-stain with two per cent. aqueous solution of vesuvin or methylene blue. (Optional)
(4) Wash in sixty per cent. alcohol.
(5) Dehydrate in absolute alcohol.
(6) Clear in oil of cloves or cedar, creosote or xylol, and—
(7) Mount in Canada balsam.

Inoculation Experiments. In the course of our experimentation we are not infrequently constrained to have recourse to inoculation experiments, by which is understood the inoculation of animals with a given material that we may test the presence of, or isolate, certain specific organisms or poisons.

If we adduce examples of instances in which it is necessary to resort to inoculation experiments it will, perhaps, convey a clearer impression and better enable the uninitiated to appreciate the importance of such experiments.

Let us suppose that the discharge from an open ulcer or the nostrils of a case in which the diagnosis is doubtful, but from certain symptoms and signs we suspect glanders, is sent to the laboratory.

If it be glanders we not only wish to recognize bacilli answering to certain prescribed dimensions and staining reactions, which are in this instance of doubtful utility, but to grow the organism in pure cultures and to produce the disease in a susceptible animal. We first secure an animal known to be susceptible to the disease—in glanders a guinea-pig—and by means of a hypodermatic syringe it is inoculated with the infective material. What is known as the method of Strauss is the best for determining the presence of and isolating the bacillus mallei, and the method may be conducted as follows:—

The suspected material is injected into the abdominal cavity of a *male* guinea-pig. If the bacillus mallei is present it quickly inaugurates its peculiar infective processes. The tunica vaginalis testis is early involved and undergoes a purulent inflammation. The exudate which covers the serous membrane is quite adherent and contains numbers of the specific bacilli. The infective process extends from the tunica vaginalis to the testicle itself, which exhibits, in addition to inflammatory redness and swelling, miliary nodules.

If the animal be examined three or four days after the intraperitoneal injection the scrotum will appear red and shining, the epidermis desquamating or suppurating, and, sometimes, purulent matter from within the scrotum discharging by perforations in the integument.

The animal should be killed at the end of the third or fourth day and, with proper precaution, tubes of agar, or preferably potato, inoculated with material from either the tunica vaginalis testis or testicle. A guinea-pig will usually live about five or six weeks, and a field mouse, which is even more susceptible, three or four days.

To obtain pure cultures of tubercle bacilli we often inoculate rabbits, either injecting the infective material into the abdominal cavity or into the groin. In the latter case the inguinal lymphatics soon become the seat of tubercular deposits and inoculation of tubes made from the gland under aseptic precautions will result in the cultivation of pure growths.

The diagnosis of anthrax in man is sometimes confirmed by inoculation experiments upon animals, and so with many diseases.

Feeding experiments are somewhat of the nature of inoculation experiments and the results attained of equal importance.

As a practical illustration of this method we may cite the cases of meat poisoning at Welbeck and Notts, England, mentioned in the chapter on Food. The meat, which constituted the principal item of the meal preceding the outbreak, when fed to dogs produced symptoms almost identical with those observed in the human victims, thus proving decisively the meat to be the carrier, at least, of the poisoning element.

Examination of Sputum. The examination of sputum will often enable a physician to make a diagnosis after all the other methods have proven unsatisfactory.

Preparations are made by spreading the sputum over a cover-glass, care being taken not to make the film too thin. The sputum may be spread by means of a looped platinum needle, a spreader specially made for the purpose, by a match-stick, or wooden toothpick. The film is dried in the air and then passed three times through the flame of a spirit lamp or Bunsen burner.

In examining for tubercle bacilli avoid the light, frothy, and thin mucus and select that which has more consistency.

The preparation is stained by one of the methods detailed on a previous page, the selection of the method depending upon the organism for the detection of which the examination is being conducted.

Blood.

Blood may contain as parasites members of either the vegetable or animal kingdom.

Of the vegetable it is only those members of the schizomycetes which demand attention, as the blood of man has never been found to contain as an etiologic factor of disease members of either the hypomycetes or saccharomycetes, with the possible exception of actinomyces, the definite classification of which is still unsettled.

Among the schizomycetes which have been found in the blood are the bacillus anthracis, bacillus typhosus, bacillus tuberculosis, bacillus mallei, bacillus tetani (?), streptococcus erysipelatis (?), and the spirillum of relapsing fever.

The following method may be adopted in preparing blood for microscopic examination to determine the presence of micro-organisms :—

The tip of a finger is thoroughly cleansed by a nail brush with soap and water, washed with sterile water, and then with a 1-1000 solution of corrosive sublimate. Immerse the finger in alcohol to remove all traces of the sublimate solution and complete the process by pouring a little ether over the finger tip and allowing it to evaporate. Puncture the finger quite deeply with a sterilized needle. The first drop of blood which flows from the wound is swept away with a sterilized platinum needle; when sufficient blood has again flowed from the wound it is brought into contact with a perfectly clean cover-glass. Another cover-glass is immediately laid upon the first with the drop of blood between. By gently pressing the cover-glasses the blood forms into a thin layer; grasp each cover-glass by a pair of forceps and separate them; each will be found covered by a thin film of blood. The covers are then dried in the air or in an exsiccator carefully protected from draughts and dust. When the film has become perfectly dry the covers are passed three times through the flame of a Bunsen burner, or spirit lamp, with the prepared side directed upward. Place the preparations, finally, in an incubator or other apparatus where a temperature of 120° F. may be maintained for several hours. The preparation should now be stained and mounted. For staining microörganisms the methods of Gram, Weigert's modification of Gram, Löffler's method, described under staining, and Günther's method, described below, are applicable. The organisms may be stained by any of the basic anilin dyes in two per cent. aqueous solution; but the result will not be so satisfactory as when one of the above mentioned methods are employed.

Anthrax. The bacillus anthracis occurs in the blood of man and animals suffering from anthrax. It sometimes happens that in persons who present symptoms identical with those of anthrax, no bacilli can be detected in the blood; to make certain diagnosis, therefore, it becomes necessary to inject a few drops of the blood into a mouse or guinea-pig. If anthrax bacilli are present the animal will soon exhibit symptoms of the disease, and if its blood is now examined the bacilli will be found in abundance. For staining the bacilli prepare cover-glass films of the blood, as previously detailed, and stain by Löffler's method, which gives the most excellent results.

Tuberculosis. Prepare the cover-glass as described and stain by one of the methods under section on Staining.

The bacillus tuberculosis is present in acute general miliary tuberculosis. They are, usually, few in number and may at times elude detection.

Glanders. The bacillus mallei is found in the blood of persons and animals suffering from glanders. They may be at best stained by Löffler's method. There is no staining method which will with certainty distinguish this bacillus, nor will its growth on the various culture media. To make a positive diagnosis we are compelled to resort to inoculation experiments. (See page 414.)

Typhoid Fever. The bacillus typhosus has been repeatedly found in the blood of typhoid fever patients. For fuller description of this organism see section on Examination of Feces. (See page 422.)

Spirillum of Relapsing Fever. The spirillum of relapsing fever is said by many observers to be present in the blood only during the paroxysms, and for this reason the blood should always be examined during the fever exacerbation. The objective used should be a one-twelfth inch oil immersion in conjunction with an Abbé condenser, small aperture. The spirilli when brought into view will appear as wavy, hair-like lines several times as long as the diameter of a red corpuscle and having a quick vibratile movement.

v. Jaksch and Sarmow have observed during the interval between the paroxysms, and more especially when an outbreak is impending, certain diplococcus-like refractive bodies. With the onset of the disease these bodies seemed to develop into short, rod-like forms, which gradually lengthened, and finally formed spirilli. v. Jaksch calls particular attention to the clinical importance of these bodies, which he thinks are probably the spores of the spirilli. They being present in the blood of those only who are suffering from relapsing fever, they will serve to characterize this disease.

To detect the spirillum of relapsing fever in dried cover-glass preparations, the procedure advocated by Günther is the most reliable. Cover-glass spreads are prepared in the usual way. Immerse the spread for ten (10) seconds in a five per cent. solution of acetic acid; by this step the coloring matter of the red corpuscles is destroyed. Drive off as much of the acetic acid as possible by blowing upon the cover glass. Neutralize what acid remains by holding the cover glass, film-side down, over the open mouth of a flask or bottle containing strong aqua ammonia ; the escape of the ammonia fumes is augmented by previously shaking the container.

Stain the preparation in the Ehrlich-Weigert gentian- or methyl-violet-anilin-water solution. Mount in Canada balsam or xylol.

Many other microörganisms have been found in the blood, including those of tetanus (?), erysipelas (?), and suppuration. Prepare cover-glass spreads, and stain by one of the methods given, if it is desired to examine for any of these organisms.

Animal Parasites.

Malaria. According to eminent authorities the hematozoön of malaria exists in three distinct forms, and each form is characterized by giving rise to certain peculiar and well-marked clinical phenomena, necessitating the division of malaria into three clinical varieties, each of which is sharply differentiated from the other.

Hematozoön of Tertian Ague. If the blood be examined a few hours subsequent to a fever paroxysm, it will be observed to contain small, motile bodies, with pale outlines, having from one to three pigmented thread-like processes of extreme tenuity. Plehn and v. Jaksch claim to have seen bodies of this description during the apyrexial period.

The parasite penetrates into the substance of the red blood-corpuscle within twenty-four hours after the subsidence of the fever paroxysm. In the corpuscle it appears as an actively moving, deeply pigmented body. The pigment, probably the hemoglobin of the corpuscle, is disposed chiefly in the periphery and serves to sharply differentiate it from the corpuscle. The parasite develops and ultimately becomes a large, motile, pigmented mass of protoplasm which completely fills the corpuscles. The attacked corpuscles, deprived of their hemoglobin, become extremely pale. After reaching its full development the parasite undergoes segmentation and the attacked corpuscle is disintegrated. In two days more the endoglobular development is completed ; another generation of hematozoöns is brought to maturity, and as they are now set free in the blood the fever paroxysm again manifests itself.

Hematozoön of Quartan Ague. The earlier development of this parasite is quite similar to that just described, though the decoloration of the red corpuscle is not so rapid and the pigment granules are larger.

What serves particularly to distinguish this parasite from the foregoing is the manner of segmentation. First, the segments are fewer, the number being from six to twelve; and, second, the process of segmentation is more regular and requires a longer time.

The quotidian type is, according to Golgi, the result of the blood being infected by three broods of the quartan variety maturing on successive days.

Hematozoön of Acyclical Ague and anomalous forms. Just before the onset of the fever paroxysm in persons suffering with this form of the disease the blood is seen to contain small, circular bodies deeply pigmented in the center, and having long, delicate, but irregular flagella; also, very small bodies endowed with ameboid movement and large, round, immobile, almost colorless forms, having a circular spot of pigment either in the center or at the periphery.

These parasites are unlike the two previously described in that they preserve their motility for a long period.

Many forms of the malaria parasite have been described, and for the sickle-shaped organisms which Lavaran first described is proposed the name Lavarania malariæ; for the other forms recognized as belonging to typical varieties of malaria is proposed the term Hemameba malariæ.

To detect this organism it will be necessary to use a one-twelfth oil-immersion lens and an Abbé condenser, medium aperture of diaphragm.

It will be much better, however, to stain the specimen, and in this way eliminate errors which might otherwise occur.

The method for staining the parasite may be conducted as follows: Dissolve in a 0.6 per cent. salt solution sufficient methylene blue to deeply color the solution; filter it, then set aside in several sterilized test-tubes, each of which is charged with a small quantity. Thoroughly cleanse the tip of a finger, and place upon it a drop of the staining fluid, and through the drop prick the finger with a clean needle. After the flowing blood has mixed with the staining solution, it is brought in contact with a thin cover-glass, and the cover-glass, with the prepared side downward, is placed upon a slide, and by gentle pressure the mixture of stain and blood spread into a very thin layer. To prevent evaporation ring the cover-glass with paraffin wax. The parasites both within and without the corpuscles are stained a light blue, and, although some unaffected corpuscles may take the stain, they are readily distinguished by the uniformity of the staining.

To make a permanent preparation, spread the blood in a very thin layer and treat in the usual way. Stain in eosin-methylene blue solution, which, according to Plehn's formula, is as follows:—

Concentrated watery solution of methylene blue, ...	60 parts
Eosin, .5 per cent. solution, in 75 per cent. alcohol, . . .	20 “
Distilled water, ...	40 “
Caustic potash, 20 per cent. solution, ...	a few drops.

The effect of this solution is to stain the parasites blue, the red corpuscles light red, leucocytes light blue, nuclei deep blue, and the eosinophil granules of the leucocytes a deep red.

The *filaria sanguinis hominis*, as found in the blood, is the larva of the adult worm which inhabits the lymphatics. The disease is found only in the inhabitants of very warm climates.

The parasite is to be found in the blood only at night; therefore, all investigations undertaken to demonstrate its presence must be conducted at night.

Feces.

A casual biological examination of the feces may be made either by placing a small quantity of feces upon a glass slip, covering it with a circle, and then pressing it out in a thin layer, or by putting a sample of feces in a sterile test-tube or other suitable vessel and adding several times its bulk of sterile water; then setting aside the vessel in a cool place for several hours and examining the sediment as above. When it is desired to make cultures, collect the feces in an aseptic napkin or a sterile vessel. As the vegetable and animal parasites are of the greatest interest to the sanitarian and physician, and time and space being at a premium, they only will be considered.

Koch's Comma Bacillus. The cholera bacillus is most readily detected by the method of Schottelius. A small quantity of the stool is placed in a glass capsule containing an equal amount of alkaline meat broth. The mixture is incubated for twelve hours in a temperature of 30 to 40° C. The cholera spirillum forms a pellicle which may be transferred to a cover-glass, stained, and mounted. Plates and tubes of gelatin, etc., are inoculated from this pellicle.

Chemical tests have been developed for distinguishing cultures of Koch's spirillum. The indol reaction first described by Bujwid and by Dunham may be obtained by adding to bouillon cultures, which have been incubating for twelve hours, or gelatin cultures after liquefaction, a few drops of pure sulphuric acid. If the cholera spirillum is present, a reddish-violet or purplish-red color quickly appears. The spirillum of Metschnikoff also develops this reaction under the same conditions.

For staining cover-glass preparations, watery solution of basic anilin dyes may be employed. They remain in the stain twenty minutes, are then rinsed in one-half per cent. solution of acetic acid, followed by immersion in water. They are dried in the air and mounted in Canada balsam. Babes recommends for section placing them in a watery solution of fuchsin for twenty-four hours, washing in water faintly acidulated with acetic acid or in a 1 : 1000 bichlorid solution, passed rapidly through alcohol, cleared in clove oil, and mounted in balsam. Finkler-Prior describes a comma bacillus in cholera nostras which is larger than the Koch spirillum. The rôle of this organism as an exciting cause of disease is still nebulous.

The *typhoid bacillus* is quite difficult to separate from the stools. It may be accomplished by agar plating; nutrient agar containing 0.2 per cent to 0.5 per cent. carbolic acid is a useful adjunct in isolating this organism.

Parietti's method has been tested by other investigators and has given satisfactory results, especially in isolating the typhoid bacillus from water. The solution he employs is made by adding together five parts of carbolic acid, four parts of pure hydrochloric acid, and a hundred parts of distilled water.

The procedure is as follows: Several test tubes are charged with 10 c.c. each of neutral bouillon and sterilized. To each tube add from three to nine drops of the acid solution. Place them in the incubator for forty-eight hours, when, if no growth develops, add from one to ten drops of the suspected water. If the bacilli are present, the bouillon becomes turbid after twenty-four hours. By plating pure cultures of the typhoid bacillus may be obtained.

The method proposed by Hazen and White has also been favorably reported upon. The operation of the test may be conducted as follows: Plate the suspected water in agar-agar plates. Incubate at a temperature of 40° C. If typhoid fever bacilli are present they will develop in the form of colonies in the course of two or three days. This test is based upon the fact that the common bacilli of water do not thrive well, if at all, at a temperature of 40° C., while this is the optimum temperature for the typhoid bacillus.

Theobald Smith asserts that typhoid fever bacilli do not produce gas when grown in culture media containing cane, grape, or milk sugar, and may be in this way distinguished from the bacillus coli communis and bacillus of hog cholera. The authors do not think that much confidence should be put in this test, and if used at all, it should only be to confirm other tests.

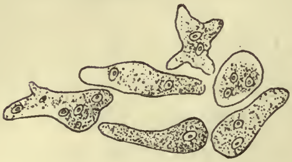
To stain cover-glass spreads of the bacillus typhosus float the cover glass, film down, upon a 2 per cent. aqueous solution of gentian violet for twenty-four to forty-eight hours at a temperature of 100° F. Rinse in .5 per cent. acetic acid in water, wash in distilled water, dry in the air, and mount in balsam.

The bacillus tuberculosis in feces is detected by preparing cover-glass spreads and the special staining method previously described. (See p. 413.)

The parasitic protozoa include members of the Rhizopoda, Gregarines, and Infusoria.

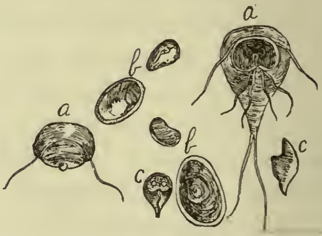
Rhizopoda. Ameba coli are round or slightly oblong and contractile bodies with a diameter of 20 to 35 μ. The protoplasm is granular and quite highly refractive in the active stage; they contain a round nucleus and hyaline vesicles. The ameba have no distinct cell wall. They often enclose red blood corpuscles, pus cells, microörganisms, and other microscopic objects with which they come in contact. The ameba coli are usually found in small, jelly-like masses, though they may at times be so numerous as to be found in any portion of the stool.

Fig. 134.



Ameba coli (*After Leuckhardt.*)

Fig. 135.



a. Megastoma entericum (*Grassé*) *b.* Cercomonas intestinalis, Encysted Forms. *c.* Cercomonas intestinalis after the Loss of its Tentacles (*Lambl.*) (*After Jaksch.*)

Gregarines. Sporozoa. Coccidium perforans, found infesting the liver and intestinal mucous membranes, are elliptical-shaped bodies with a long diameter of 22 μ. They have a cell wall and enclose granular nuclei which are, for the most part, massed to the center. The coccidia are usually found in large numbers.

Infusoria Cercomonas intestinalis, a pear-shaped organism, the length of which is from 10 to 12 μ. They possess two terminal filaments, one about as long as the organism and rigid, the other much longer and very delicate, and which during life is the organ of locomotion, as by its rapid vibrations the cercomonas is propelled. The cercomonas is frequently found in cholera, typhus, typhoid, and other acute or chronic diarrheal conditions.

Fig. 136.

Cercomonas. (*From Leuckhardt.*) *a.* Larger variety. *b,* smaller variety.

Trichomonas intestinalis. The body, 15 μ in length, is pear-shaped, and somewhat more bulging than the cercomonas. It possesses a tail and a lateral ciliated comb, which usually consists of about twelve cilia. This organism is destitute of flagella.

Paramecium coli. The body is symmetrical, short, and oval, measuring 0.07 to 0.1 mm. long by 0.05 to 0.07 mm. broad. The anterior end, which appears truncated, has a short peristome extending inward to the right and terminating in a gullet. The anal opening at the posterior extremity is not distinct. The paramecium coli is covered with cilia, contains a slightly bent elliptical nucleus and two contractible vacuoles which lie on the right side.

Tenia. The diagnosis of tapeworm may be made with the microscope, even before the appearance in the stool of the proglottides, by detecting the eggs in the feces. To examine for the eggs of tapeworms place some of the feces in a jar with distilled water and from day to day decant the water and then immediately replace it with fresh water until the greater bulk of the feces have been dissolved. A small quantity of the sediment should be mounted in glycerin and examined by a medium power objective, when the eggs, if present, will be readily detected. If one has proglottides, or the head of a tapeworm, and wishes to ascertain to what species it belongs, mount it in glycerin and examine with a low power objective, that the characteristics of the specimen may be clearly observed.

Tænia mediocanellata: The head of this parasite contains four large, deeply pigmented suckers, and is devoid of a rostellum and hooklets. The length of the segments increases very gradually. The uterus is branched, more so than that of the T. solium, while at the side of the proglottis is to be seen the genital pore.

Tænia solium: The head of the tænia solium is of a somewhat quadrilateral form, measuring about $\frac{1}{40}$ of an inch, and is of a dark color. It has four large, circular suckers, between which is the rostellum, a prominent rounded elevation, having around the margin two rows of hooklets. The hooklets number about twenty-six and those of the anterior row are the larger. Near the head the proglottides are broader than they are long, but as they recede from the head the length increases much faster than the breadth, so that about three feet from the head the proglottides become nearly quadrilateral. The branching of the uterus (Fig. 48, p. 150) is not nearly so well developed as in the T. mediocanellata, and the genital pore opens slightly behind the middle of the segment.

Bothriocephalus latus: The head, measuring $\frac{1}{12}$ inch long and $\frac{1}{25}$ inch broad, is egg-shaped and flattened. It has two lateral suctorial grooves. Hooks may be present, but if so are without a rostellum. The proglottides are broader than they are long, but the difference is not so marked as they recede from the head. The particular characteristic of this tapeworm is in the rosette arrangement of the uterus.

Microscopic Examination of Meats. To make a rapid examination of meat, the Germans employ an instrument made of two pieces of plate glass 8 inches by 1½ inches. The lower plate is about ⅜ of an inch thick and marked by transverse lines dividing it into twelve spaces. At each end is placed an upright brass post with threads cut for a milled thumb-screw. These poles pass through holes in the upper glass plate. The upper plate is ⅛ of an inch thick, has a longitudinal marking $\frac{4}{5}$ of an inch wide, and numbers from 1 to 24 over the spaces of the lower plate. A section of meat is cut, placed between the glass plates, the thumb-screws tightened, and the meat pressed out in a very thin layer. This is placed under a low power of the microscope and examined. The number of the diseased and suspicious sections are noted, then if desired or if necessary a more critical examination may be made. By this procedure a great number of specimens may be examined by an expert in a very short space of time. Fig. 137 shows an American compressor which is manipulated in the same manner as the German instrument, though it is without markings and divisions.

Fig. 137.

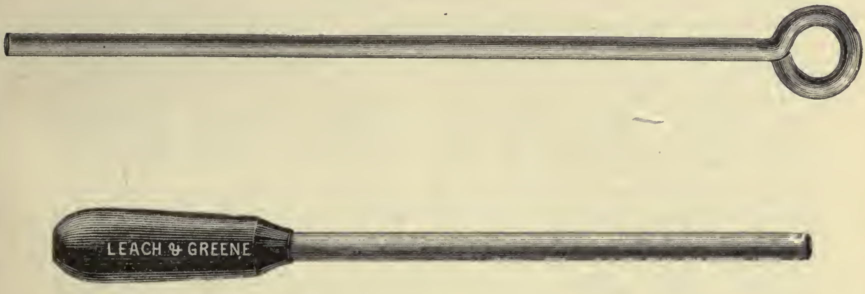
The American Compressor.

Warren's Cannula, a cut of which is shown in Fig. 138, is used for removing specimens of tissue from the living animal. In using the instrument the cannula is introduced deeply into the tissue, slightly withdrawn, and again forced in, but this time at an angle so as to completely sever the segment within the cannula at the bottom. The cannula with specimen is wholly withdrawn and the rod introduced at the upper end; as the rod is pushed through, the segment of tissue in the lower end of the cannula is forced out.*

Tuberculosis. Prepare and stain specimens of sputum or any other discharge by one of the methods already detailed. The gross lesions have been described on page 143. If any doubt exists as to the nature of the lesions, stain and mount according to the Koch-Ehrlich method (page 414.)

Actinomyces. The appearance of actinomyces is so characteristic (see Fig. 7) that it cannot be at the present time confused with any known organism. All collections of fluid, the diagnosis of which is obscure, should be critically examined for the fungus. Prepare cover-glass specimens and sections in the usual way and stain by one of the following methods:—

FIG. 138.



WARREN'S TROCAR AND CANNULA.

Plaut's Method. Stain sections for two hours in Neilson's carbo-fuchsin solution, or, if the solution be maintained at a temperature of 40° C., it will only be necessary to stain for from 20 to 30 minutes. Wash the sections in distilled water and then immerse for ten minutes in a saturated alcoholic solution of picric acid. Again wash the section in distilled water, then in 50 per cent. alcohol, and finally transfer to absolute alcohol to dehydrate, clear in cedar oil, and mount in balsam.

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* This instrument was devised by Dr. Warren, of Boston, and was originally intended to remove pieces of tissue from morbid growths, that diagnoses might be made or confirmed before operative interference.

Wethered recommends staining the fungus in a five per cent. aqueous solution of rubin for ten minutes, then washing in distilled water until the sections are of a delicate pink color, when they are transferred for three minutes to absolute alcohol. Place the section upon a glass slip and stain according to Weigert's modification of Gram's method.

Anthrax. Sections of the diseased meat are prepared and stained by Weigert's method; or the juice expressed from the tissues is spread on cover glasses and stained by same method. As anthrax is rapidly fatal in mice, usually producing death within twenty-four hours, we may resort to inoculation experiments to confirm our diagnosis.

Glanders. The bacillus mallei may be found in the discharge from the ulcerated nasal passages, also in the discharge from the ruptured "farcy buds" and from the surface of the ulcers. The bacillus mallei is quite difficult to stain; the best method may be obtained by Löffler's method modified, as already described.

Trichina spiralis. Preparations are best made by teasing with fine needles a thin, longitudinal section of muscle, preferably taken from the diaphragm, either end of the masticatory muscles, abdominal or the intercostal muscles, as these are the most likely to be the muscles affected. Place the specimen on a glass slip and cover it with acetic acid or a solution consisting of liquor potassa, 1 part, water 10 parts, until it becomes transparent, wash the specimen in water, clear and mount in glycerin. If the capsule should be calcified dissolve the lime salts in a weak solution of hydrochloric acid. (See Fig. 50, page 151.)

After singling out a cyst, rupture it with a fine needle, turn out upon a slide the trichina; this performance may be repeated several times. Stain the trichina with Ranvier's picrocarmin and mount in glycerin or Farrant's medium. When the mounting is completed examine the specimen under a magnifying power of from 50 to 100 diameters. A low-power examination may be made by a compressor as already described.

Hyatid Cysts affect particularly the liver and peritoneum, though none of the soft tissues are exempt. The disease is due to the cystic form of the tænia echinococcus localizing in the tissues. In this country it is seldom met. The fluid of the cyst is non-albuminous, hence, no precipitate is obtained by treating with nitric acid or by heating. To examine the fluid microscopically fill a conical glass and set aside until sedimentation occurs. Withdraw some of the sediment, mix it with Farrant's medium, and mount. If examined under a low power the scolices may be seen as round or somewhat oval bodies with at one end a disc of a dark color. These bodies are granular and, frequently, may be seen in them the suckers and hooklets. The hooklets may be detected, also, free in the fluid even after suppuration has occurred. These characteristic bodies will appear, when lying flat, as sickle-shaped, with broad, humped bases. Peculiar bodies, having a slight resemblance to the hooklets of the echinococcus, are sometimes observed in cysts of an entirely different nature and may be misleading when seen for the first time. If, however, the slides are kept for twenty-four hours, or if the fluid be examined twenty-four hours after removal, these bodies will have completely disappeared.

Skin Diseases.

Several members of the hypomycetes or mold fungi are proven to be the etiologic elements in certain diseases of the skin. Thin, filamentous organisms were long ago ascertained to be constantly associated with favus and tinea tonsurans, and more recently Grawitz has conclusively proved them to be the exciting causes.

The peculiarity of the parasitic mold fungi is that, with the exception of two species, they are to be found only in the superficial layers of the skin. The various mycoses of the skin and the responsible organisms may be enumerated as follows:—Favus, Achorion schönleinii; Tinea tonsurans, Trichophyton tonsurans; Tinea versicolor, Microsporon furfur; Tinea sycosis, an organism closely allied if not indentical with T. tonsurans.

Tinea versicolor: The microsporon furfur may be found in the upper layers of the epidermis. The scales should be placed in dilute liquor potassa for several minutes, gently washed in distilled water, and mounted in glycerin or Farrant's medium,* The organism will be brought clearly into view when examined

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* *Farrant's Medium :*

Gum arabic (picked),	4 drams
Camphor water,	4 fluidrams
Glycerin,	2 "

Mix, dissolve by gentle heat over water bath, filter through muslin.

by a one-sixth inch objective, with medium aperture in diaphragm. The hyphæ are seen disposed in the form of a network seen upon the surface of cells, and scattered here and there may be observed the conidia.

In favus, tinea tonsurans, and tinea sycosis the organisms are to be found in the scabs, investing the hairs, and often, particularly in favus, penetrating into the root-sheath and forming by their hyphæ a perplexing interlacement.

Hairs plucked out by the roots, or scabs, may be treated as described above for the demonstration of the microsporon furfur, when the organism will be clearly discerned.

Thrush. The oïdium albicans or thrush fungus is to be found in the white patches which form in the mouth of persons suffering from thrush. It, like other members of the oïdium family, is capable of forming a mycelium, and from this peculiarity, though the cells when cultivated in media containing large quantities of sugar are more like the torula, many observers class it among the hypomycetes.

To detect the organism detach a portion of the neo-membrane and mount it in glycerin. Examined with one-sixth-inch objective and small aperture in diaphragm the fungus will be seen as long branching filaments composed of segments. The segments are of various lengths and become much smaller toward the ends of the filaments. Bright refractive bodies may be seen in the segments, and about the filaments certain oval bodies supposed to be the conidia.

Scabies. This disease is caused by the itch mite, an animal parasite which infests the skin.

The itch mite, or acarus scabiei, may be found wandering over the surface of the body (male) or in furrows in the skin (female).

The adult acarus has a round body with projecting head and eight legs. The four front legs are provided with suckers and the four hind ones are covered with hairs.

In the male the innermost pair of the posterior four are also furnished with suckers.

The female, which is larger than the male, measures about $\frac{1}{60}$ of an inch in length.

Young acari have but six legs previous to the shedding of their skin, after which may be seen eight developing legs. The eggs of the parasite measure about the $\frac{1}{90}$ of an inch in length and the $\frac{1}{200}$ of an inch in width.

After securing an itch mite it may be mounted in glycerin or Farrant's medium; first, however, treating it with dilute solution of caustic potash and washing in distilled water.

Examine with a low-power objective, medium aperture in diaphragm, without condenser.

Leprosy. The bacillus lepræ may be obtained by clamping a nodule and thoroughly cleansing the surface in the same manner as described under section on Blood, then puncturing the nodule with a sterilized needle. Touch the cover-glass, previously thoroughly cleansed, to the fluid which escapes from the puncture and immediately apply over it another cover-glass. Spread the drop into as thin a layer as possible and separate the cover-glasses. Dry the film in the air and then pass it through the flame of a Bunsen burner or spirit lamp, and stain by one of the following methods:—

Baumgarten: Float the cover-glass, film down, upon a dilute alcoholic solution of fuchsin for ten minutes, treat with acidulated alcohol (nitric acid 1 part, alcohol 10 parts) for fifteen seconds, rinse in distilled water, and contrast stain with one per cent. aqueous solution of methylene blue for twenty minutes, wash in distilled water, dry in the air, and mount in balsam. The leprosy bacilli are stained red and the background blue. Tubercle bacilli do not stain in so short a period.

Lustgarten: Stain with the anilin-water-gentian-violet, or -fuchsin, described under tubercle staining, and bleach in a one per cent. sodium chloridate solution for thirty minutes or so, and then wash thoroughly in distilled water. Tubercle bacilli are more readily decolorized than the lepra bacilli in this solution.

Lepra bacilli have been found in sputum.* One peculiarity of this bacillus is the exceedingly perplexing groups in which it is so often found.

The writers have obtained the best results in staining tissue

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* A few months ago, the authors were shown by Dr. Sommer a few of his preparations of the sputum obtained from a leper at the Municipal Hospital, in which the bacilli were to be discerned in considerable numbers.

containing this organism by treating the section for twelve hours with the anilin-water-gentian-violet solution. After staining, the sections are first rinsed in distilled water to remove the superfluous stain, then treated for one minute in the tincture of chlorid of iron, rinsed for a few minutes in distilled water, and then in acetone for five minutes; finally, in xylol, dried, and mounted in xylol balsam.

Tetanus. The specific organism of this disease is an anaërobe, and may be found in the discharges from wounds of persons suffering from traumatic tetanus. It is quite a widely distributed organism and may often be discovered in superficial strata of earth and in the street sweepings from large cities. It is isolated from other organisms by subjecting substances containing spores to a temperature of 80° C. for one-half hour to one hour. Suitable tubes are inoculated and the air in the tube displaced with hydrogen (see Anaërobic Cultures). It stains by the basic anilin colors and by Gram's method; by Ziehl's double staining method the spores and bacilli are both stained. To demonstrate its presence in wound discharges and in earth recourse is frequently had to inoculation experiments. Mice, rabbits, and guinea pigs are especially susceptible to the bacillus tetani.

Croupous Pneumonia. The organism of this disease (micrococcus pneumoniæ crouposæ) may be distinguished from the pneumo-bacillus of Friedländer, which it much resembles, in the manner of its staining. The micrococcus pneumoniæ crouposæ stains by the anilin colors and Gram's method, while by the latter method Friedländer's bacillus is decolorized. Inoculation experiments may be necessary to confirm its presence; if so, rabbits will be found very susceptible to this poison.

Rhinoscleroma. The bacillus which is found constantly associated with this disease is by many regarded as the etiologic factor. The bacilli are present in the newly formed tubercles, in the lymphatic spaces, and contiguous tissues also, and most commonly in the large hyaline cells peculiar to this affection.

The method adopted by Alvarez to demonstrate their presence may be used to advantage. Small pieces of diseased tissue are placed for twenty-four hours in a one per cent. osmic acid solution, washed well in flowing water, and hardening completed in absolute alcohol. Thin sections are placed in a hot anilin-water-methyl-violet, or gentian-violet solution for a few minutes, treated by Gram's method, and mounted in balsam.

Erysipelas. The streptococcus erysipelatis may be obtained from the contents of the blebs which form over the affected area in this disease. Many consider this organism and the streptococcus pyogenes as identical. v. Lingelsheim is, however, of the opinion that there are two great groups of streptococci, neither of which manifest any peculiar characteristic in development nor morphology except when cultivated in bouillon. The streptococcus erysipelatis in bouillon culture does not form the conglomerate masses so characteristic of the streptococcus pyogenes, and, further, it differs from the latter in not being pathogenic for mice.

Gonorrhea. Gonococci are found in the purulent discharges which characterize gonorrhea. The organism is a peculiar roll or biscuit-shaped diplococcus, and may be distinguished from similar microörganisms by being deprived of its color when treated by Gram's method, and from the fact that it is found *within* the pus cells. The gonococci stain with methyl-violet, gentian-violet, fuchsin, and methylene blue, the latter giving the best results. To stain gonorrheal discharge, make a thin spread of it upon a thin cover-glass, and when perfectly dry pass three times through the flame of a spirit-lamp, film side up. Hold the cover-glass, film up, over the flame of a spirit-lamp and cover with an alcoholic solution of eosin. Replace the stain from a dropper as the alcohol evaporates. There is some danger of the alcohol taking fire, if it does, simply blow out the flame. Continue this process for a few minutes and then remove all superfluous stains with filter paper. Float the cover-glass, film down, upon a concentrated alcoholic solution of methylene blue for thirty seconds. Wash in distilled water for a few minutes, then in sixty per cent. alcohol for four or five minutes; dry in the air and mount in Canada balsam or dammar.

Protoplastic masses of leucocytes, pus cells, etc., are stained a delicate pink, the nuclei a slightly darker red color, and the gonococci blue.

Syphilis. The bacilli of syphilis may be found in discharges from the primary lesion and syphilitic ulcers, and in other syphilitic lesions. Sections are stained according to Lustgarten's method, which is as follows: Stain sections from 12 to 24 hours in the anilin-water-gentian-violet solution, and two hours before removing the sections maintain the stain at a temperature of 60° C. From the stain the sections are transferred to absolute alcohol, then to a 1.5 per cent. solution of permanganate of potash for ten minutes, and then for one minute in concentrated sulphurous acid. This process must be repeated until the sections are completely decolorized. The sections are immersed in absolute alcohol to dehydrate; cleared in oil of cloves, and mounted in Canada balsam.

APPENDIX.

METRIC SYSTEM—ENGLISH.

Unit of length,	the meter.
" " capacity,	" liter.
" " weight,	" gram.

1 Meter	=	the ten-millionth part of a quarter of the earth's circumference at the equator.	= 39.37	inches.
1 Liter	=	the capacity of the cube of $\frac{1}{10}$ of a meter	= 33. 8	Troy ounce.
1 Gram	=	weight of distilled water, at point of maximum density, 4° C., which fills the cube of $\frac{1}{100}$ of a meter.	= 15.434	grains.

Multiples of these are expressed by the Greek prefixes, as Deca, ten; Hecto, one hundred; Kilo, one thousand; Myria, ten thousand.

Fractional parts are denoted by Deci, one-tenth; Centi, one-hundredth; Mille, one-thousandth.

1 Meter	=	3.28	feet	=	39.37	inches.			
1 Decimeter	=	.33	"	=	3.94	or about 4	inches.		
1 Centimeter	=	.93	"	=	.39	or "	$\frac{4}{10}$ inch.		
1 Millimeter	=	.003	"	=	.039	or "	$\frac{1}{25}$ inch.		
1 Micro-millimeter	=	$\frac{1}{1000}$ of a millimeter or approximately $\frac{1}{25000}$ inch.							
1 Decameter	=	10.	meters	=	32.8	feet	=	393.7	in.
1 Hectometer	=	100.	"	=	328.	"	=	3,937.	in.
1 Kilometer	=	1000.	"	=	3,280.7	"	=	39,371.	in.
1 Myriameter	=	10,000.	"	=	32,807.	"	=	393,710.	in.

1 Liter	=	1,000.	cubic centimeters	=	33.8	fluid ounces.
1 Deciliter	=	100.	" "	=	3.38	" "
1 Centiliter	=	10.	" "	=	2.70	" drams.
1 Milliliter	=	1.	" "	=	.27	dr. or 16.2 minims.
1 Decaliter	=	10,000.	" "	=	2.641	gallons.
1 Hectoliter	=	100,000.	" "	=	26.419	"
1 Kiloliter	=	1,000,000.	" "	=	264.19	"
1 Myrialiter	=	10,000,000.	" "	=	2,641.9	"

1 Gram	=	15.4340	grains, Troy, or $\frac{1}{4}$ of a dram.	
1 Decigram	=	1.5434	" "	
1 Centigram	=	.1543	" "	
1 Milligram	=	.0154	" "	
1 Decagram	=	154.3402	" " or about	2½ drams.
1 Hectogram	=	1,543.4023	" " " "	3⅛ ounces.
1 Kilogram	=	15,424.023	" " " "	2¾ lbs.
1 Myriagram	=	154,340.2	" " " "	26¾ "

BAROMETER SCALES.

French.			*U. S.*		*French.*			*U. S.*	
1	Millimeters	=	.039	inch	752	Millimeters	=	29.328	inch
25.4	"	=	1	"	753	"	=	29.367	"
710	"	=	27.69	"	754	"	=	29.406	"
711	"	=	27.729	"	755	"	=	29.445	"
712	"	=	27.768	"	756	"	=	29.484	"
713	"	=	27.807	"	757	"	=	29.523	"
714	"	=	27.846	"	758	"	=	29.562	"
715	"	=	27.885	"	759	"	=	29.601	"
716	"	=	27.924	"	760	"	=	29.640	"
717	"	=	27.963	"	761	"	=	29.679	"
718	"	=	28.002	"	762	"	=	29.718	"
719	"	=	28.041	"	763	"	=	29.757	"
720	"	=	28.080	"	764	"	=	29.796	"
721	"	=	28.119	"	765	"	=	29.835	"
722	"	=	28.158	"	766	"	=	29.874	"
723	"	=	28.197	"	767	"	=	29.913	"
724	"	=	28.236	"	768	"	=	29.952	"
725	"	=	28.275	"	769	"	=	29.991	"
726	"	=	28.314	"	770	"	=	30.030	"
727	"	=	28.353	"	771	"	=	30.069	"
728	"	=	28.392	"	772	"	=	30.108	"
729	"	=	28.431	"	773	"	=	30.147	"
730	"	=	28.470	"	774	"	=	30.186	"
731	"	=	28.509	"	775	"	=	30.225	"
732	"	=	28.548	"	776	"	=	30.264	"
733	"	=	28.587	"	777	"	=	30.303	"
734	"	=	28.626	"	778	"	=	30.342	"
735	"	=	28.665	"	779	"	=	30.381	"
736	"	=	28.704	"	780	"	=	30.420	"
737	"	=	28.743	"	781	"	=	30.459	"
738	"	=	28.782	"	782	"	=	30.498	"
739	"	=	28.821	"	783	"	=	30.537	"
740	"	=	28.860	"	784	"	=	30.576	"
741	"	=	28.899	"	785	"	=	30.615	"
742	"	=	28.938	"	786	"	=	30.654	"
743	"	=	28.977	"	787	"	=	30.693	"
744	"	=	29.016	"	788	"	=	30.732	"
745	"	=	29.055	"	789	"	=	30.771	"
746	"	=	29.094	"	790	"	=	30.810	"
747	"	=	29.133	"	791	"	=	30.849	"
748	"	=	29.172	"	792	"	=	30.888	"
749	"	=	29.211	"	793	"	=	30.927	"
750	"	=	29.250	"	794	"	=	30.966	"
751	"	=	29.289	"	795	"	=	31.005	"

THERMOMETERS.

COMPARATIVE SCALES.

	Fahrenheit.	*Centigrade.*	*Reaumur.*
Freezing Point,	32	0	0
Boiling "	212	100	80

To reduce degrees F. to C.:—

$$(\text{F.} - 32) \times \frac{5}{9} = \text{C.} \ \textit{e.g.}, (212^\circ \text{ F} - 32) \times \frac{5}{9} = 100^\circ \text{ C.}$$

To reduce C. to F.:—

$$(\text{C} \div \frac{5}{9}) + 32 = \text{F.}, \textit{e.g.} \ (100^\circ \text{ C} \div \frac{5}{9}) + 32 = 212^\circ \text{ F.}$$

To reduce F. to R.:—

$$(\text{F} - 32) \times \frac{4}{9} = \text{R.}, \textit{e.g.}, (212^\circ \text{ F.} - 32) \times \frac{4}{9} = 80^\circ \text{ R.}$$

To reduce R. to F.:—

$$(\text{R.} \div \frac{4}{9}) + 32 = \text{F.}, \textit{e.g.}, (80^\circ \text{ R.} \div \frac{4}{9}) + 32 = 212^\circ \text{ F.}$$

To reduce C. to R.—

$$\text{C} \times \frac{4}{5} = \text{R.}, \textit{e.g.}, 30^\circ \text{ C.} \times \frac{4}{5} = 24^\circ \text{ R.}$$

To reduce R. to C.:—

$$\text{R.} \div \frac{4}{5} = \text{C.}, \textit{e.g.}, 32^\circ \text{ R.} \div \frac{4}{5} = 40^\circ \text{ C.}$$

THERMAL DISINFECTION.[1]

Name of Organism or Disease.	Moist Heat.			Dry Heat.		
	In Spore Stage; Temperature.	Non-sporebearing; Temperature.	Time of Exposure Necessary.	In Spore Stage; Temperature.	Non-sporebearing; Temperature.	Time of Exposure Necessary.
Actinomyces (ray fungus),		160° F.	10 minutes.		216° F.	45 minutes.
Anthrax,	212° F.	168° F.	30 "	260° F.	232° F.	90 "
Cholera Asiatica,		132° F.	10 "		220° F.	30 "
Diphtheria (croup),[2]		180° F.	30 "		225° F.	70 "
Erysipelas[3]		152° F.	10 "		230° F.	50 "
Favus,		187° F.	10 "	Not known.		
Glanders (bacillus mallei),		135° F.	10 "	No experiments.		
Gonorrhea,		142° F.	10 "	" "		
Pneumonia,		142° F.	10 "		210° F.	50 "
Rabies (Sternberg)		142° F.	10 "	No experiments.		
Ringworm (various forms),		160° F.	10 "	" "		
Scarlet fever,[4]		178° F.	10 "	" "		
Micrococcus pyogenes, aureus, } Suppuration,		143° F.	10 "		227° F.	30 "
" " albus, } Suppuration,		136° F.	10 "		220° F.	30 "
" " citreus, } Suppuration,		140° F.	10 "		225° F.	30 "

Micrococcus cereus albus, Suppuration,		138° F.	10 “		223° F.	30 “
“ “ flavus,		140° F.	10 “		225° F.	30 “
Tetanus,	212° F.	212° F.	5 “		248° F.	60 “
Tuberculosis,		212° F.	15 “		227° F.	35 “
Thrush (parasitic stomatitis),[5]		212° F.	20 “		217° F.	10 “
Typhoid fever,		142° F.	20 “			
Meningitis, cerebro-spinal,[6]		212° F.	30 “	No experiments.		
Measles,[7]		160° F.	60 “	“ “		
Typhus fever,[8]		185° F.	60 “			
Variola and varioloid,[8]		190° F.	60 “		235° F.	60 “

---

[1] In thermal disinfection three things must be considered :—

1st. The kind of heat, moist or dry.

2d. The degree demanded.

3d. The length of time necessary to secure destruction of vitality. It may be safely stated that any temperature above the optimum, for any given organism, will, if sufficiently prolonged, prove fatal; on the other hand very brief exposure to a high temperature will be equally efficient. The table here given is worked out from collected data and from experiments in the writers' laboratory. Diseases in which a bacterial cause has not been demonstrated, and organisms in which spores are not known to exist are placed in the non-sporebearing class for convenience only.

[2] From experiments by Dr. Sommer in writers' laboratory, and in Municipal Hospital, Philadelphia.

[3] Same vitality as streptococcus pyogenes.

[4] Disinfection at this temperature in quarantine effectually prevented the spread of the disease from bedding upon which children were afterwards permitted to sleep.

[5] In the Sanitarium no spread of the disease ever occurred, all discharges, dressings, clothes, nipples, bottles, etc., being subjected to above temperature.

[6] Quarantine disinfection at this temperature is believed to be efficient.

[7] In case of measles which appeared on a ship, immediate disinfection of everything at above temperature, with isolation of case, arrested the spread of the disease, although many children who had not had the disease were aboard and occupied the disinfected quarters.

[8] Conclusions drawn from the practical workings of quarantine. Disinfection of clothing etc., at above temperature proved efficient.

SPECIFICATIONS IN BLANK.*

Improvement of Site, Sub-drains, Made Elevation.

Excavations,
Mason work,
Damp-proof course,
Foundations—stone and brick,
Foundation straps,
Footings.

Hollow Walls.

Beam filling,
Protecting drain,
Chimney.

Brick Work.

Coloring brick work,
Face brick,
Mortar,
Tiling,
Hearths,
Concrete or cemented floors,
Floor drains,
Terra cotta pipes, laying, etc.,
Iron—iron ties,
Hollow walls,
Inside arches,
Bond,
Center arches,
Brick floors.

Stone Work.

Chimney tops,
Cap stones,
Sills,
Copings,
Carving,
Stone hearths,
Pointing mortar,
Drips,
Stone lintels.

Plastering.

Lath and plaster, wire lathing,
Walls, sand, and hard finish,
Papering,
Lime,
Cornices, interior, centers, etc.

Carpenter's Work.

Timber, size, quality,
Headers,
Crowning and bridging,
Floor,
Ceiling, beams, and rafters,
Boarding,
Floors, double and single,
Tiling,
Windows, frames, sashes, and doors,
Transoms,
Hardware—door knobs, locks, etc.,
Mantels, picture mouldings, and stair rails,

---

* In contracting with an architect or builder for the construction of a building for dwelling, school, hospital or other purposes, the appended list is believed to cover all the important subjects which should be settled before construction is begun.

Saddles,
Partitions,
Furring,
Wooden ceilings,
Wainscoting and stairs,
Vegetable-cellar shelves,
Coal bins,
Closets, wardrobes, etc.

Plumbing.

Water-closets and cisterns,
Bath tubs and wash basins,
Sewage system,
Kitchen sinks, slop sinks, and laundry tubs,
Spiggots, kinds and finish.
Speaking tubes and bells.
Gas fitting.

Painting.

Finishing, oil or hard wood.

Glass.

Plain, plate, and stained,
Puttied or leaded.

Ventilation.

System to be used and quantity of air to be supplied.

Heating.

Method and application.
Range, stoves and furnaces.
Steam or hot-water system.

Roofing.

Roof materials,
Roof gutters, conduits, etc.

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