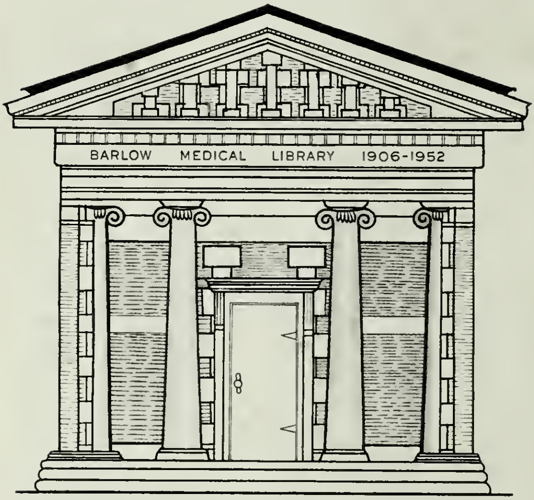
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PUBLIC HEALTH

AND

PREVENTIVE MEDICINE

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PUBLIC HEALTH

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PREVENTIVE MEDICINE

BY

C. J. LEWIS

M.D., D.Sc. (Public Health), Edin.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, EDINBURGH;
MEMBER OF THE ROYAL COLLEGE OF SURGEONS, ENGLAND;
LECTURER ON PUBLIC HEALTH, MEDICAL COLLEGE FOR WOMEN, EDINBURGH;
EXAMINER IN PUBLIC HEALTH, ROYAL COLLEGE OF PHYSICIANS, EDINBURGH;
FELLOW OF THE ROYAL INSTITUTE OF PUBLIC HEALTH;
MEMBER OF THE EPIDEMIOLOGICAL SOCIETY OF LONDON

AND

ANDREW BALFOUR

M.D., B.Sc. (Public Health), Edin., D.P.H. (Camb.)

FELLOW OF THE ROYAL INSTITUTE OF PUBLIC HEALTH;
MEMBER OF THE EPIDEMIOLOGICAL SOCIETY OF LONDON;
LATE ASSISTANT PHYSICIAN, CITY HOSPITAL (FOR INFECTIOUS DISEASES), EDINBURGH,
AND CIVIL MEDICAL OFFICER, SOUTH AFRICAN FIELD FORCE

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PREFACE.

This book is primarily intended for those studying with a view to obtain registrable qualifications in Public Health. It is hoped, however, that it will also prove of value to medical officers of health, the members of sanitary committees, and others interested in sanitary problems.

With these aims in view, the subject of Preventive Medicine has been given a prominent position, while considerable space has been devoted to Vital Statistics, Sanitary Law, and the Sanitary Works connected with drainage, water supply, and building construction. Special care has been taken to condense the information as far as possible without the exclusion of any essential points, and for this purpose headings and subheadings have been largely adopted. We trust, however, that clearness has in no case been sacrificed to concise exposition. Every effort has been made to bring the work thoroughly up to date, despite the rapid advances made in subjects relating to Public Health, and especially in Preventive Medicine.

Taking into consideration the main object of the volume, and in the endeavour to secure the utmost compression, it has been decided to exclude what would be a very lengthy bibliography, though the names of authorities are frequently quoted.

No attempt has been made to deal fully with laboratory work, but as some reference to it was absolutely necessary, the rationale of the various processes has in each instance been given, and, we believe, will be found useful by the student in the way of recalling his practical work and refreshing his memory.

Our thanks are due to all those whose writings have aided us, and also to those who in other ways have rendered us assistance. We are specially indebted to Dr. Harvey Littlejohn for much kind advice, criticism, and the loan of literature on various branches.

On the special subject of Sanatoria, Dr. Philip has kindly favoured us with the results of his extensive experience; and as regards Fevers, Dr. Claud Ker has given us valuable suggestions. We would express our obligation to

Dr. W. H. Power, of the Local Government Board, with reference to Hospital Construction and Milk Epidemics; in relation to Statistical Work, to Drs. Newsholme and Blair Cunynghame; and concerning Food, to Dr. Robert Hutchison. Dr. George Gibson has been good enough to assist us in several ways; and we would acknowledge the courtesy and kindness of Sir Henry Littlejohn; the Managers of the Royal Infirmary, Edinburgh; Robert Morham, Esq., the City Architect; James Massie, Esq., the interim Burgh Engineer; and Stephen Robinson, Esq., of Leicester, in granting us the use of various plans.

To Mr. Robert Muir, of the Pathological Department of the University of Edinburgh, we tender our sincere thanks for the admirable and careful way in which he prepared the drawings for the coloured plates and the diagrams illustrating the sections of Preventive Medicine and Food. We believe these will add very materially to the value of the volume. The specimens from which they were produced were prepared in part by the authors, and largely by Mr. Muir himself.

Mr. G. K. Green has executed most of the other drawings under our supervision, and has taken much trouble to render them clear and instructive.

Lastly, we are glad to have this opportunity of acknowledging the information derived from our former teachers, Professors Sir Henry Littlejohn, Wyllie, and Hunter Stewart, the late Professors Armstrong and Kanthack, and Drs. Leslie Mackenzie and Bushell Anningson.

C. J. LEWIS.
ANDREW BALFOUR.

EDINBURGH, *April* 1902.

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PUBLIC HEALTH

AND

PREVENTIVE MEDICINE

MEDICINE.

In the consideration of Medicine in its relation to the Public Health, there are included not only the Infective and Parasitic Diseases, but also those engendered in the course of various occupations and trades. Further, those diseases induced by an alteration in the quantity or quality of food and drink, or by an adulteration of food and drink, have to be considered. It is therefore proposed to deal with the subject under the following headings:—

1. COMMUNICABLE OR INFECTIVE DISEASES.
2. PARASITIC DISEASES.
3. DISEASES OF OCCUPATION.
4. DISEASES OF ALIMENTATION.

I. COMMUNICABLE OR INFECTIVE DISEASES.

At the outset it is necessary to mention certain common terms which are too often inaccurately distinguished one from the other. Such terms as contagious, miasmatic, miasmatic-contagious, and inoculable have been in use for longer or shorter periods, and have given rise to considerable confusion, owing to advances in our knowledge of the etiology and spread of disease. Thereby the accepted definition of these designations has been considerably modified. We propose, therefore, to discard, as far as possible, this somewhat misleading nomenclature, and instead of classifying diseases under these headings, to deal in each case with the methods of transmission.

These methods of transmission may be stated as follows:—

(1) Aerial.
(2) Alimental.
(3) Fomital.
(4) Telluric.
(5) Corporeal. { *Direct.* / *Indirect.* }

Aerial.—This signifies transmission of the virus through the atmosphere, and its reception into the human body by means of an abraded or unabraded mucous membrane or by an abraded skin surface. A disease may be communicated in this manner through considerable distances, as in the case of conveyance of the poison by exhalations, cutaneous desquamations, dried excreta, and desiccated sputum.

Alimental.—By this method is meant the transmission of the virus through the medium of food or drink. The term includes the important class of water-borne diseases and those induced by the ingestion of infected milk and meat.

Fomital.—Under this heading comes the transmission of the virus by means of fomites, inanimate objects, such as clothing, furniture, letters, etc., and its entrance by an abraded skin surface, or by an abraded or unabraded mucous membrane.

The term fomital is conveniently placed as a separate class, although in reality composed of subdivisions of the aerial and direct corporeal.

Telluric.—This term implies direct transmission from the soil to the human body, and its entrance therein by an abraded skin surface, or, more rarely, by an abraded or unabraded mucous membrane.

Corporeal.—This class requires subdivision into—(*a*) Direct, (*b*) Indirect.

Direct corporeal relates to the immediate transmission of the virus from a man or an animal suffering from the disease.

Indirect corporeal signifies mediate transmission of the virus from a man or an animal, suffering from the disease, by the aid of an intermediate living agent, which is not itself affected, and merely acts as a carrier of the poison.

To take four well-known examples of communicable disease.

Enteric fever may be spread by the dried dust of stools infected with the typhoid bacillus, conveyed either by wind, by the act of inspiration, or by flies and other animals. Hence it is classed as aerial and indirect corporeal.

It may also be conveyed to the human system by means of water or milk. Hence it is alimental.

Strictly speaking, enteric fever is not a telluric disease, as, though the soil may contain the bacillus, its introduction into the human body is, of necessity, by means of air or aliment. The same remark applies to its relation to the class fomital.

Malaria, inasmuch as it has been proved that the disease is transmitted to man by insects, is indirect corporeal. It is also, as will be shown, aerial and alimental.

Plague.—The organism of plague is transmitted directly from the soil through the abraded skin. Hence plague is telluric. Further, it is aerial, fomital, and, owing to the proclivity of rats for the disease, and the fact that they convey it to man, it is also direct corporeal.

Smallpox is largely aerial. It is also fomital and direct corporeal.

A second set of terms falls to be discussed. These are Endemic, Epidemic, Pandemic, and Sporadic, and they one and all relate to the prevalence of disease.

Endemic refers to a disease confined to a particular area, and more or less constantly present therein, local circumstances having much to do with its persistence. *Example.*—Typhus fever.

Epidemic refers to diseases affecting large numbers of persons, and not of necessity confined to a limited area. *Example.*—Measles.

Pandemic refers to an epidemic disease simultaneously spread over large areas of the earth's surface. *Example.*—Plague.

Sporadic signifies scattered, and is applied to diseases or cases of disease which may spread, but are not epidemic.

(The whole question of Infection is discussed in association with Disinfection, p. 264.)

THE COMMUNICABLE DISEASES.

These are divided into the Epizootic and the Non-epizootic; epizootic signifying a disease primarily affecting the lower animals, being transmissible from one to the other, and occasionally to man.

EPIZOOTIC DISEASES.

Actinomycosis.

Geographical Distribution.—Throughout temperate latitudes.

Etiology.—This is a disease produced by the ray fungus, which is one of the streptothrices. These belong to the higher bacteria, and are characterised by non-septate filaments showing true dichotomous branching. They are intermediate between the bacteria and the fungi. The streptothrix in question is a vegetable parasite growing upon certain of the cerealia. The infection takes place most commonly from barley, probably owing to laceration produced by the sharp spike (awn) of the barley grain in the skin or in the mucous membrane of the respiratory and the digestive tracts. Further, milk from an infected mamma may be the vehicle of transmission.

Description.—To the naked eye the ray fungus appears in the tissues as small, circular masses, varying in size from a mere speck to a pin's head, and in colour from a translucent white to an opaque yellow or greenish grey, the opacity increasing with the age of the colony. They are, as a rule, soft, but may be gritty, owing to calcareous deposit. Microscopically, the colony is seen to be composed of a central mycelium, formed of interlacing and branching filaments, while at the periphery there are club-shaped structures formed by an expansion of the free ends of the filaments. In and between the filaments bodies resembling cocci are commonly present, the true nature of which requires elucidation. Both filaments and cocci retain the stain in Gram's method (Plate I. Figs. 1 and 2). Actinomyces is capable of cultivation on nutrient media, and grows best at 37° C. in broth and on agar and on glycerine agar. It slowly liquefies gelatine. On solid media, such as blood serum, it appears as small spherical masses of an amber-yellow colour (Fig. 1), and, when thus artificially cultivated, tends to occur in the form of filaments, clubs being rarely produced. In human actinomycosis filaments form the main feature, while in the bovine variety clubs are more commonly produced. It can grow both aerobically and anaerobically.

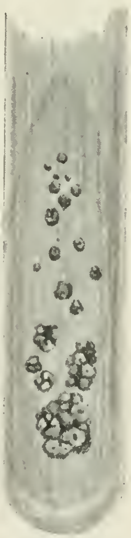


Fig. 1.—Actinomyces; culture on agar; four weeks' growth.

The ox is the animal most frequently affected, the disease being usually localised to the tongue and jaws, hence giving rise to the name "wooden tongue" (Plate I. Fig. 3). Occasionally the skin or lungs are involved. In the human being the parts affected are more varied, even the female genital tract having been invaded, while the respiratory and alimentary tracts, in addition to the tongue and jaw, are frequently the seats of lesion.

In the tissues there is a chronic inflammatory change, resulting in the formation of abscesses containing greenish yellow pus, in which colonies of the parasite are present. In the ox there is more induration and tumour formation than is the case in man. Metastatic abscesses may occur in internal organs, especially the liver, but in cattle the disease tends to be localised and to spread by continuity.

Differential Diagnosis.—Distinguish from new growths and from abscess formation due to other organisms.

Method of Transmission.—Directly from the infected grains, and also through the milk, as already stated. As far as is known, the disease cannot be transmitted from the lower animals to man by direct contact. Direct transmission of the disease by contact from one individual to another is extremely rare, only one case having been recorded.

Prevention of Origin and Spread.—Inspection of grain and condemnation of any diseased carcase or cereal intended for human food.

Anthrax.

Syn., Splenic Fever, Charbon, Woolsorters' Disease.

Geographical Distribution.—It is not endemic in this country, but in Europe it is endemic in Catalonia and the Romagna, while it is common in Poland, Hungary, Saxony, and parts of France. It is also found in India, Africa, America, and Australia.

Fig. 2.—*B. anthracis;* culture in gelatine; one week old growth.

Etiology.—Anthrax is caused by an organism known as the *Bacillus anthracis.* Microscopically this organism appears in the blood of an animal dead of the disease as a large, non-motile bacillus, square-cut at the ends, apparently possessing a capsule, which is best seen when several of the bacilli form a chain, as they so often do. This appearance has been likened to a number of railway carriages placed end to end (Plate I. Fig. 6). In broth, after twenty-four hours' incubation at 37° C., there is some turbidity, and an appearance of fine white floating threads, which at a later period sink to the foot of the tube as a flocculent mass. On agar the growth is thick, grey, and felted, while in gelatine stab culture it is very characteristic, resembling an inverted fir-tree, owing to the outward spread of numerous fine spikes, which are longest at the upper part of the stab (Fig. 2). Liquefaction spreads from above downwards.

Agar-plate cultivations are thicker at the centre than at the periphery, and with their wavy outlines closely resemble fine seaweeds as these appear when mounted on cardboard. When artificially cultivated the bacillus forms large spores, giving it a beaded appearance (Plate I. Fig. 5). The bacillus can be stained by the ordinary anilin dyes, and is not decolorised by Gram's method.

The non-pathogenetic *B. mycoides* of the soil closely resembles the anthrax organism in morphology, but it is slightly motile, presents erect fir-tree growth in gelatine stab, and is decolorised by Gram's method.

Description.—Human Anthrax.—The *incubation period* varies with the channel of infection and the quantity and virulence of the virus.

The *Symptoms* are usually present within forty-eight hours, and the persons most liable are drovers, farmers, farriers, veterinary surgeons, slaughterers, and butchers. Tanners, fellmongers, wool-, hair-, and horn-workers, rag-sorters, plasterers, furriers, and felt-makers are also prone to the disease.

There are three varieties of human anthrax:—

1. *Malignant pustule*, which affects the exposed parts of the body; beginning as a papule, and passing through a vesicular stage, accompanied by much induration and extensive inflammation, in which the lymphatics may be involved. After forty-eight hours, constitutional symptoms supervene, in the form of pyrexia, delirium, pains, and prostration. The disease may terminate fatally in from five to eight days.

2. *Intestinal anthrax*, which is invariably fatal, and, as a rule, is only recognised upon the post-mortem table. From a public health standpoint, the important symptom is melæna, the stools containing the specific organism.

3. *Pulmonary anthrax.*—Here the lesion is found in the respiratory tract. If the patient survives a week, he as a rule recovers.

Animal Anthrax.—Oxen, sheep, horses, and pigs are chiefly affected.

In cattle there are three main varieties:—(1) A rapidly fatal type, with coma and convulsions; (2) a remittent, febrile type, with spasms and sometimes melæna; (3) brawny, gelatinous swellings, cutaneous or subcutaneous, which lead to ulcer formation.

Differential Diagnosis.—Anthrax has to be distinguished from boil, carbuncle, phlegmonous erysipelas, cellulitis, chancre, glanders, malignant œdema, and progressive gangrene.

Recurrence.—One attack may confer slight protection, but does not insure complete immunity.

Method of Transmission.—This is most commonly by means of infected hides and fleeces, hence the term "woolsorters' disease." In such cases it takes the form of malignant pustule or pulmonary anthrax. The most dangerous fleeces are those derived from Pan in Armenia, from the region of the Caspian, and from South America. A fleece is dangerous in proportion to its dryness and dustiness, properties dependent upon the absence or paucity of the "yolk," as the natural soap of the skin is called. Goat-hair is consequently more dangerous than sheep's wool, while hair from the alpaca, llama, vicuña, camel, horse, and cow has no "yolk."

The picking of Russian horse-hair, paper-making, and the manufacture of coarse woollen hats may also lead to infection. It is to be noted that infected imported materials may convey the disease to animals in this country. The hair, hides, or fleeces are washed, and the water is turned into streams or sewers, while any solid refuse from the washing is used as manure. Such facts may explain the distribution of the disease in certain parts of England.

The ingestion of diseased meat, milk, or butter, contact of an abraded surface with soil contaminated by excreta or carcases, the drinking of water containing the spores, the inhalation of infected dust, as from dried stools, the bites of animals or insects which have fed on infected tissues, and direct contact with the living animal, provided an abrasion be present in the person running the risk, are all means whereby the disease may be transmitted. In alimentary and respiratory anthrax the spores alone convey the disease.

There is no evidence to show that suctorial insects can transmit anthrax.

Prevention of Origin and Spread.—In Animal Anthrax.—Prohibition of the removal of animals from premises on which anthrax has broken out.

Isolation and destruction of infected animals.

Disposal of carcases by burning or by burying in quicklime, care being taken to prevent infection of streams or water supplies, and the spilling of infected fluids and excrement upon the ground. In this connection it should be mentioned that the spores are much more highly resistant than the bacilli themselves, and for efficient disinfection both must be destroyed. A soil containing a *little* lime, and thus being alkaline in reaction, greatly favours sporulation.

Disinfection of byres and burning of bedding.

Prophylaxis may be secured by inoculation with the attenuated virus, or with small doses of certain chemical products of the bacterial growth.

IN HUMAN ANTHRAX.—*Notification.*—Under the Factory and Workshops Act, 1901, every medical practitioner is bound to notify cases of anthrax to the Home Office.

Condemnation of infected carcases and food-stuffs as unfit for food.

Cauterisation and early excision in the case of malignant pustule.

Disinfection of discharges and fomites.

In the event of death, rapid burial or, preferably, cremation. In the case of factories, etc., the adoption of the sanitary precautions enforced by the Town Council of Bradford (p. 297).

If, without impairing the value of the infected materials for trade purposes, they could be subjected to efficient disinfection by steam, a valuable precautionary method against the introduction of anthrax would be secured.

Foot and Mouth Disease.

Syn., APHTHA EPIZOOTICA.

GEOGRAPHICAL DISTRIBUTION.—General; probably introduced to Britain from the Continent.

ETIOLOGY.—The disease is probably due to a streptococcus which can be cultivated on ordinary media, and renders milk acid without curdling. When grown artificially, the colonies are seen to be more transparent than those of other known streptococci.

DESCRIPTION.—IN ANIMALS.—Cattle and sheep are affected, horses rarely attacked; but pigs may contract the disease from the milk of infected cows. It is a febrile complaint associated with vesicle formation on the mucous membrane of the mouth, lips, and tongue, and on the udder and teats, as well as about the hooves. The organism is present in the buccal saliva, in the vesicular fluid, and in the milk of cows with affected teats. The disease lasts a fortnight, and is not very fatal, except in the case of cows, where the mortality is high, probably owing to intestinal irritation.

IN MAN.—The *incubation period* is from three to five days.

SYMPTOMS.—There is slight fever, formation of papules, and then of painful vesicles on the buccal mucous membrane, and sometimes round the nails of the fingers and between the toes. The vesicles break down and form small ulcers, while there is often diarrhœa and colic.

METHOD OF TRANSMISSION.—*Direct corporeal*, the virus gaining admission by the abraded skin or mucous membrane.

Indirect corporeal, as when farm-servants carry the disease from one locality to another.

Plate I.

Fig 1

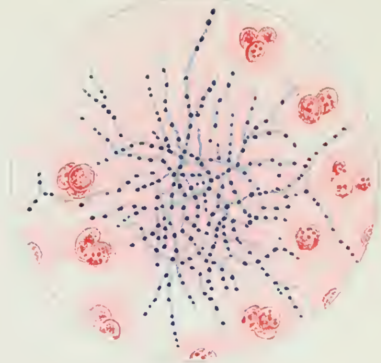


Fig 2

Fig 3

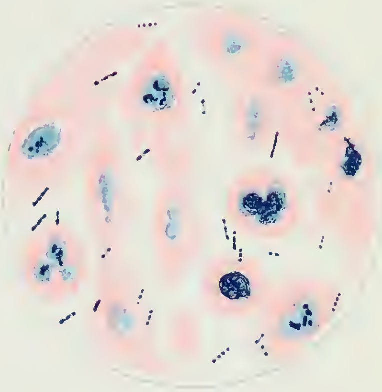


Fig 4

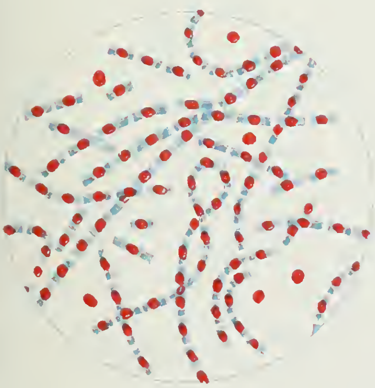


Fig 5.

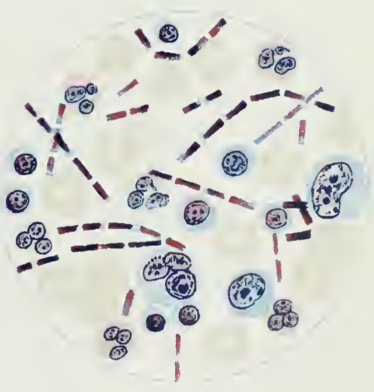


Fig 6.

Figure 1.—*Actinomycosis.* Abscess in human liver (× 40 diam.). Gram's method.
,, 2.—*Pus from case of Actinomycosis*, showing filaments of Actinomyces (× 1000 diam.). Gram's method and saffrin.
,, 3.—*Actinomycosis.* Tongue of cow (× 500 diam.). Acid fuchsin and methylene blue.
,, 4.—*Glanders Bacilli* in scraping from gland (× 1000 diam.). Eosin, meth. and thionin blue.
,, 5.—*Anthrax.* 3 days agar culture, showing spores (× 1000 diam.). Fuchsin and meth. blue.
,, 6.—*Anthrax.* Scraping from spleen of guinea pig (× 1000 diam.). Thionin blue.

Alimental, by means of the milk, which, by the way, tends to coagulate when boiled. Butter made from the milk may also convey the virus.

Fomital, the virus adhering to inanimate objects and being conveyed long distances, as in railway waggons, straw, hay, manure, etc.

Prevention of Origin and Spread.—Condemnation of milk from infected animals.

Isolation of infected animals.

Disinfection of discharges.

Precautionary measures in the case of wounds and abrasions.

Glanders.

Syn., Farcy.

Geographical Distribution.—General.

Etiology.—The *B. mallei* is the cause of glanders. The bacillus is a straight or slightly curved rod with rounded ends. It is non-motile, and is characterised by irregular staining (Plate I. Fig. 4). It is doubtful if the bacillus forms spores. The organism is best stained by carbol-thionin-blue, and is decolorised by Gram's method. Culturally its growth on agar is grey, but it flourishes best on blood serum and potato, occurring on the former as round, clear drops, and on the latter as a honey-coloured growth (Fig. 3), which subsequently becomes brown or chocolate coloured, and is highly characteristic.

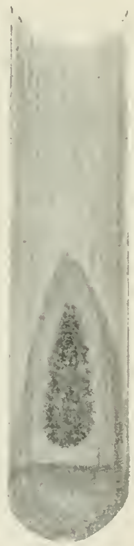


Fig. 3. — *B. mallei*; three weeks' culture on potato.

Description.—The *incubation period* is from twenty-four to forty-eight hours.

Symptoms.—In Animals.—Horses, asses, and mules are specially liable, guinea-pigs and cats may be attacked, but cattle are not susceptible. There are two varieties—(*a*) Glanders proper, affecting the nasal mucous membranes and causing ulceration; (*b*) farcy, characterised by the production of "buds" or nodules in and beneath the skin, the lymphatics being affected and the limbs frequently swollen. These "buds" break down, forming abscesses and finally ulcers.

In Man two forms are described—(*a*) Acute, (*b*) chronic.

(*a*) *Acute.*—It is usually fatal in about a fortnight. There is often fever and malaise, a pustular eruption passing through papular and vesicular stages, and an ulceration of the nasal mucous membrane spreading to adjoining parts. Acute farcy is very fatal, usually within three weeks.

(*b*) *Chronic.*—It is a prolonged ulcerative condition affecting the skin, the regions of joints, and mucous membranes. It results in profound cachexia, and may pass into the acute form.

Differential Diagnosis.—Acute glanders has to be distinguished from various fevers, acute rheumatism, pyæmia, and septicæmia; the chronic variety from tubercle and syphilis.

Method of Transmission.—*Direct corporeal*, as from a bite, or contact between the discharge and a wound or abrasion.

Fomital, as from infected clothes or horse-rugs.

Possibly alimental, from ingestion of diseased meat. Such, however, has often been eaten with impunity.

Prevention of Origin and Spread.—Disinfection of fomites and discharges, the resistance of the bacillus being feeble to heat and antiseptics, though it long withstands the effects of putrefaction.

Isolation of infected animals.

Condemnation of diseased meat.

In animals, diagnostic and prophylactic inoculation with mallein, a product of the culture of the *B. mallei* in glycerine broth.

Hydrophobia.

Syn., Rabies.

Geographical Distribution.—World-wide, except in Australia, where it has never occurred, and in Sweden, where precautionary measures have stamped it out.

Etiology.—The specific poison is unknown, but exists in the saliva and spinal cords of infected animals. It has never been isolated or artificially cultivated.

Description.—In Animals.—The *incubation period* is from three to six weeks. The dog, wolf, and cat are specially affected, and there are two types —furious rabies and paralytic rabies.

Furious rabies is characterised by irritability, restlessness, and, in the dog, altered bark. There are spasms of the pharyngeal muscles, accompanied by salivation and difficulty in swallowing. Fear of water is not a symptom, but the animal tears and worries generally, and tries to eat out-of-the-way substances.

Paralytic rabies is distinguished by paralysis of the jaws, loins, and hind legs, salivation, and, in the dog, the same altered bark. The disease is invariably fatal to dogs, usually in about one week, and is more frequent during the hot summer months.

In Man.—The *incubation period* varies from seven days to two years. Men and children are more often attacked than women, owing to the nature of the latter's clothing and their mode of life.

Symptoms.—Healing takes place at the seat of inoculation, and afterwards there is uneasiness about the scar, with restlessness, irritability, and repugnance to fluids. Convulsions of the muscles of respiration and deglutition supervene, occurring in severe paroxysms. Death is due to exhaustion or suffocation.

Differential Diagnosis.—Distinguish from hysteria, insanity, tetanus, and acute ascending paralysis.

Method of Transmission.—It is not known to have been transmitted from man to man. Inoculation usually takes place from the bite of an animal suffering from the disease, the virus being contained in the saliva, but a case is recorded in which the poison was acquired by inoculation of a wound during dissection of a rabid animal.

Prevention of Origin and Spread.—Efficient muzzling of all dogs for at least a year, and collection and destruction of all ownerless dogs.

Destruction of rabid animals.

On meeting with a case of rabies in man, the essential treatment is to—(*a*) Cauterise the wound; (*b*) secure preventive inoculation by Pasteur's method, which consists in taking advantage of the long period of incubation, in order to inoculate the patient with a modified and protective form of the disease. It is possible to do so, owing to the fact that the period of incubation of the disease in rabbits and guinea-pigs is much shorter than that in man. The patient is inoculated with an attenuated virus obtained from the spinal cords of rabbits which have been inoculated with canine rabies. Hence the patient takes a mild form of hydrophobia before the severe attack, which would otherwise have been induced by the bite, can manifest itself. The inoculation has to be repeated, commencing with mild doses and gradually using more and more virulent virus. Such gradations of virus are easily secured, because it is found that the virulence of the poison increases when passed through a succession of rabbits and guinea-pigs. The patient receives injection at first from spinal cords which have been kept in a dry state for fourteen days. In these, owing to the treatment to which the cords have been subjected, the virus is weak. Injections derived from more and more recent specimens are then given, till finally the patient can receive so active a virus as one derived from a cord a day old. By means of this treatment the case mortality of hydrophobia has been much reduced, though the sooner a patient is subjected to it the better are the results.

The Italian method of immunisation consists in attenuating rabic virus by submitting it to peptic digestion, immunising a sheep or dog therewith, and employing the blood serum of such an animal as a preventive.

Madura Foot.

Syn., Mycetoma.

Geographical Distribution.—*India and the tropics.*—It is an endemic disease of rural districts.

Etiology.—It is produced by a streptothrix resembling actinomyces, but differing in that it does not liquefy gelatine, has a reddish colour when grown on agar, and will not grow anaerobically.

Description.—*Incubation period* uncertain.

Symptoms.—It is a local and chronic disease, most frequently affecting the foot, and consists of a slow nodular growth of the nature of a granuloma, causing great deformity, and, it may be, abscess formation and caries of bone. Metastatic abscesses, however, are never produced. The oily pus contains granules, which have been likened to fish-roe, and are somewhat like those of the ray fungus. There are three varieties—yellow, black, and red, and the disease has been known to occur internally as a primary lesion.

Mortality.—It is usually fatal after a long period.

Method of Transmission.—Probably through the skin from the surface of a plant on which the streptothrix lives.

Prevention of Origin and Spread.—No known means.

Malignant Œdema.

Geographical Distribution.—Widespread.

Etiology.—It is due to a specific organism, the bacillus of malignant œdema, whose chief habitat is garden soil. Microscopically, this organism appears as a large rod slightly thinner than the *B. anthracis*, which it otherwise closely resembles, but it is slightly motile, possessing a few laterally-placed flagella. It forms oval spores, and is readily stained by any of the basic anilin dyes. It is decolorised by Gram's method. Culturally, it is anaerobic (Plate II. Fig. 1) liquefies gelatine, and produces gas.

Description.—The disease is a spreading gangrenous inflammation with emphysema of the skin.

Method of Transmission.—Contamination of lacerated wounds by garden soil, dung, or putrefying animal fluids containing the bacillus.

Prevention of Origin and Spread.—Cleanliness and the protection of abrasions. In animals, immunity can be secured by injection of sterilised cultures and of protective serum.

Vaccinia.

Syn., Cowpox.

This is the disease produced in the human being—(1) By transmission of the virus from a cow suffering from cowpox. Thus, infected udders may contaminate the abraded hands of a milkmaid. (2) By vaccination, the process of protecting human beings from smallpox by the inoculation into them of cowpox, maintained by propagation of the disease through several generations of calves, the lymph from which is used for the inoculation. (3) By vaccination, the process of protecting human beings from smallpox by the inoculation into them of cowpox, maintained by propagation of the disease through several generations of human beings, whose lymph is used for the inoculation.

Geographical Distribution.—Wherever vaccination is practised.

Etiology.—Unknown. The relations between variola and vaccinia and the rationale of vaccination are discussed on pp. 30, 283.

Description.—The disease affects cattle, and similar complaints are known to occur in the horse and sheep.

Incubation period.—Three days.

Symptoms.—Pale red papules develop at the seat of inoculation. These become vesicles and then pustules. The pustules become umbilicated, their contents dry up, and they eventually form scabs, which drop off leaving scars. There may or may not be slight constitutional symptoms.

Differential Diagnosis.—Distinguish from smallpox and chicken-pox.

Recurrence.—One attack confers immunity for a varying time ; it may be for life.

Method of Transmission.—*Direct corporeal.*

NON-EPIZOOTIC DISEASES.

The Exanthemata.

The exanthemata are febrile diseases characterised by the presence of skin eruptions. In discussing them, allusion will be made to two terms which require definition.

Quarantine, in the sense here used, signifies the period during which a person who has been exposed to the risk of infection may develop the disease, and ought to be isolated.

The *striking distance* of a disease expresses its power of communicating its virus as regards space. Thus the poison of smallpox can be transmitted at long ranges, while typhus fever has a very short striking distance.

Cerebro-Spinal Fever.

Syn., Epidemic Cerebro-Spinal Meningitis.

Geographical Distribution—At one time this disease was supposed to be confined to the Northern Hemisphere. It is now known to have a greater range, having been described at Khartoum, in Ashanti, and in India, though chiefly found in various parts of Europe and the United States.

Etiology.—It is due to the *Diplococcus intracellularis* of Weichselbaum (Plate II. Fig. 2), found in the cerebral and spinal exudation post-mortem. It has been obtained during life from the spinal canal by lumbar puncture, being most easily found in the first week of the disease. It has been demonstrated in the nasal secretions of living patients, as well as after death. When found in the tissues, it occurs in the polynuclear leucocytes. Outside the body it is very resistant when in a dry condition, adhering to fomites, and is believed, in India at least, to have a habitat in dust.

It occurs as single round cocci, diplococci, tetrads, and short chains, and in the second variety a considerable space intervenes between the two globules.

Cultural Characteristics.—On artificial media the colonies have a poor vitality, the organism tending to rapidly attenuate. Blood serum forms the best medium, and, as on sloped agar, a delicate greyish streak develops, with isolated grey dots spread over the medium at the margins of the main growth. In broth a marked opacity is produced, but there is only slight invisible growth on potato. Gelatine is not liquefied. In agar-plate cultivation the deep colonies are small and scarcely visible, the superficial are larger and greyish white.

Staining.—It stains well with thionin-blue and watery solutions of methylene-blue, but is decolorised by Gram's method.

Description.—Average *incubation period* is from two to seven days. Epidemics may vary much in severity, and there are several types of the disease.

1. *Fulminant*, which is sudden in onset, rapid in course, and fatal in result. It occurs chiefly at the beginning of epidemics, and may kill the patient in two hours' time. Its average course is, however, one to three days.

2. *Abortive.*—The symptoms are slight and indefinite, and it ends in recovery usually within four or five days. The patient may not be incapacitated from work. Such cases occur during the decline of an epidemic.

3. *Typical.*—The invasion is sudden, associated with and followed by headache, vomiting, rigidity of the neck muscles, fever, affections of the special senses, and a cutaneous eruption, which may be of the nature of herpes, roseola, erythema, urticaria, or purpura. Delirium and coma may precede a fatal result, which usually takes place within a fortnight. The symptoms may abate within fourteen days, and recovery take place. In the Bhagalpur outbreaks in India the duration of fatal cases was from three to fifteen days.

4. *Purpuric*, so called from the appearance of the eruption.

5. *Intermittent*, characterised by remissions of temperature. The periods of apyrexia may last for several days.

6. *Typhoid.*—A clinical condition common in protracted cases of this

and other fevers, and characterised by muttering delirium, a dry, brown tongue, sordes on the lips, and involuntary evacuations.

7. *Relapsing*, in which convalescence is interrupted by the recurrence of fever.

A point of some importance, as regards the public health, is the fact that cerebro-spinal fever is frequently followed in infants by deaf-mutism.

Differential Diagnosis. — Distinguish from simple or tubercular meningitis, enteric fever, typhus fever, pneumonia, malaria, and influenza.

Mortality.—The mean case mortality is about 40 per cent.

Incidence.—*Age.*—The predisposing conditions are such that the disease is most common amongst children, though not unknown even in the old. The reason will be apparent when it is stated that persons living under insanitary conditions are peculiarly liable, and that poverty, starvation, dirt, damp, overcrowding, and want of air and sunlight, are all factors in the causation. Over-exertion seems also to play a part.

Sex.—Males are more frequently affected than females; in the tropics, soldiers and male prisoners tending to be attacked.

Climate.—It is to be noted that in the tropics the disease is rare under the age of twenty.

Season.—It is most prevalent in winter and spring, and in this connection it is curious that many cases occur in India during April, the dusty month.

Locality.—The disease is apt to appear in prisons, workhouses, and barracks.

Method of Transmission.—Probably *aerial*, from breath inhalation or dried nasal secretions. The question of transmission by the agency of wind-borne dust, as from roof accumulations and the process of grain cleaning, has to be kept in mind as regards cases in the tropics. It is remarkable that in a series of forty-seven prison cases in India, forty-four of the patients followed dusty occupations, while the remaining three carried on indoor work (Buchanan).

The disease is very slightly communicable from person to person, but it may be *direct corporeal*, as a somewhat similar complaint has been observed amongst pigs and dogs when the fever was prevalent. No attendant was affected in the prison cases.

It is certainly *fomital*. The diplococcus has been found on a handkerchief six weeks after its use by a patient.

It has been suggested that it may gain access to the cerebro-spinal system through the nasal cavity.

Prevention of Origin and Spread.—Isolation is advisable for a period of fourteen days.

The sputum, nasal secretions, all fomites and buildings, must be thoroughly disinfected. All rags used by the patient must be burned.

Methods for allaying dust may prove useful.

Dengue.

Syn., Dandy, Break-bone Fever.

Geographical Distribution.—Dengue occurs chiefly in India, the West Indies, Burmah, Mauritius, and the Levant. Like yellow fever, it hugs the coast lines. South of the equator it is not found out of the

PLATE II.

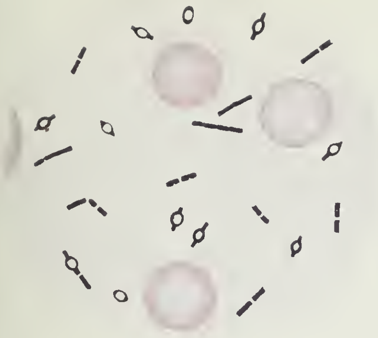


Fig 1.

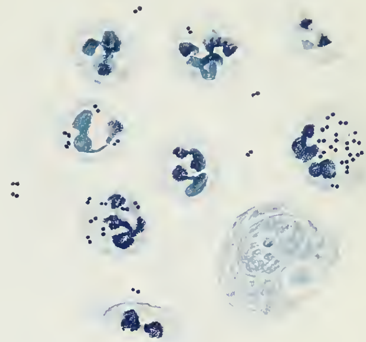


Fig 2

Fig 3

Fig 4

Fig 5

Fig 6

FIGURE 1.—*Malignant Œdema.* Film preparation from tissue (× 1000 diam.). Gentian violet.
" 2.—*Cerebro-spinal Fever, Meningococcus* in spinal fluid (× 1000 diam). Thionin blue.
" 3.—*Typhoid Bacilli* from 24 hours agar culture (× 1000 diam.). Fuchsin.
" 4.—*Typhoid Bacilli,* showing flagella (× 1000 diam.). Muir's flagella stain.
" 5.—*B. Coli Communis,* 12 hours agar culture (× 1000 diam.). Meth. blue.
" 6.—*B. Coli Communis,* 12 hours agar culture, showing flagella (× 1000 diam.). Löffler's method.

tropical belt, while its northern limit in the Eastern world is 41° N., and in the Western, 39° N.

Etiology.—A micrococcus has been described in the blood, but proof that it is the cause of the disease is lacking.

Description.—*Incubation period* about four days.

Symptoms.—The invasion is sudden, associated with fever, articular pain, and swelling, and an initial and fleeting rash, followed by a period of remission of all the symptoms, lasting three days. Then occurs a second polymorphous rash, with or without fever, and pain in the joints; and, finally, resolution with a protracted convalescence.

The spread of an epidemic is extremely rapid and general, large numbers of persons of all ages and races being affected, and an epidemic usually lasts from two to seven months. Like influenza, it predisposes to other and more fatal diseases.

Differential Diagnosis.—Distinguish from rheumatic fever, scarlatina, yellow fever, rubeola, and malaria.

Mortality.—Trifling, death occurring chiefly amongst infants and old people.

Incidence.—*Age.*—All ages affected.

Sex.—No marked predisposition for one sex more than another.

Season.—Occurs chiefly in the hot season of the year, but is not markedly dependent on weather conditions.

Race.—All races equally liable.

Recurrence.—One attack usually confers immunity.

Method of Transmission.—*Aerial.*

Prevention of Origin and Spread.—Isolation for ten days or a fortnight.

Enteric Fever.

Syn., Typhoid Fever, Gastric Fever.

Geographical Distribution.—It occurs in all parts of the world, in either an endemic or an epidemic form.

Etiology.—It is due to the *B. typhosus*, an organism which microscopically is a short, extremely motile and flagellated rod with oval ends. It is not known to produce spores. In a hanging-drop preparation of a young culture, the appearance may not inaptly be likened to that of an excited crowd of fish in a disturbed fish-pond.

Cultural Characteristics.—The bacillus grows best at 37° C., both aerobically and anaerobically, but its growth on solid media is very slow. In broth it causes a uniform turbidity, on agar and gelatine stroke it presents a bluish grey film which is not characteristic, while in gelatine stab the needle track shows an opaque, whitish, finely nodular line, and there is no liquefaction or gas formation (Fig. 4). On gelatine plate the colonies grow very slowly, especially when in the substance of the jelly, where they form small round points. Those on the surface are larger, and appear as bluish white films, with wavy margins. On fresh potato the growth is characteristic, owing to the fact

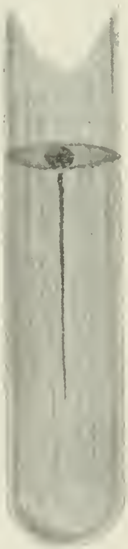


Fig. 4.—*B. typhosus* in gelatine; one week old culture.

that when apparently none is present, an extensive development has in reality taken place, so that, looking sideways at the culture, a moist, glistening area is observed, from which a scraping can be taken, in which the organism is abundantly present. In litmus broth faint acid production takes place, while the bacillus grows freely in milk, causing a similar reaction, without coagulation of the medium. In 1 per cent. peptone broth the freshly cultivated bacillus produces no indol within one week, but after ten to twelve weeks' cultivation at 37° C., indol is produced. In casein-peptone solution the typhoid bacillus produces indol in less than a week, and in alkali-peptone bouillon it does so by the fourth generation, a generation signifying a three days' growth. Gas formation does not accompany growth in glucose jelly.

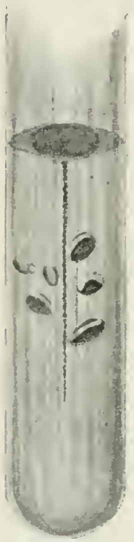


Fig. 5. — *B. coli communis* in gelatine; two weeks' growth.

Staining.—The bacillus is easily stained by the ordinary anilin dyes, and is decolorised by Gram's method (Plate II. Fig. 3). The demonstration of the flagella, which are numerous, project from all parts of the rod, and are very long, requires special staining by the methods of Van Ermengen, Löffler, Pitfield, or Muir (Plate II. Fig. 4).

An important method of recognising the bacillus is the agglutination test, which may be performed macroscopically or microscopically.

The bacillus is easily killed by heat, but is very resistant to cold, and can live in ice for months. It can grow in direct sunlight and in the X-rays.

It is found in the blood in not more than 25 per cent. of cases, according to Kühnau's researches, but occurs in the splenic pulp, in the liver, kidneys, mesenteric glands, at certain stages in Peyer's patches, in post-typhoidal abscess, and in the bone marrow in cases of osteomyelitis following enteric. It is also frequently present in the fæces, and occasionally in the urine, and can be demonstrated in the stools during the first ten days of the fever. Thereafter it is probably killed off by the numerous coliform bacilli. In the urine the typhoid bacillus has been found after the second or third week of the fever, and during convalescence. The frequency with which this occurs has been variously stated. Out of forty-five cases Lewis only found it in one case, but Horton-Smith and Richardson demonstrated it in 25 per cent. of the cases they examined, and Petruschky in 6 per cent. These variations can probably be explained by the severity or otherwise of the attack. Typically the bacillus is present in pure culture and in enormous numbers, while pyuria frequently coexists. The organism may also occur in mixed culture, associated with the *B. coli communis* (Plate II. Fig. 5) or pyogenic organisms.

The group of coliform bacilli resemble the *B. typhosus* in several respects. Some of the distinctions between them are tabulated, and the points in which they resemble each other are also stated.

DIFFERENCES.

	Bacillus Typhosus.	Bacilli Coli Communis.
Morphology.	Extreme motility.	Moderate motility; sometimes very active.
	Flagella longer (Plate II. Fig. 4); more numerous, 8 to 12, and more wavy.	Flagella shorter; fewer, less wavy. There may be only one terminal flagellum (Plate II. Fig. 6).
Culture.	Slow growth in ordinary media.	Rapid growth in ordinary media.
	Colony on gelatine plate examined with the low power and lacerated with the point of a platinum needle, shows busy bee-hive appearance—workers!	Colony on gelatine plate examined with the low power and lacerated with the point of a platinum needle shows sluggish bee-hive appearance—drones!
	Does not form gas in jelly shake and stab cultures.	Forms gas in jelly shake and stab cultures (Fig. 5). (A few rare forms do not produce gas.)
	No gas in glucose jelly culture.	Abundant gas in glucose jelly culture.
	In semi-liquid jelly at 37° C. produces diffuse cloudiness.	Not so diffuse.
	In mixed culture of typhoid and coli on semi-liquid jelly plate at 27° C., or on semi-liquid agar jelly at 37° C., the growth is peripheral, due to great motility.	Under these same conditions growth is central, owing to moderate motility.
	Milk is not coagulated.	Milk is coagulated, but not invariably.
Chemical.	Transparent film on fresh acid potato.	Brown pellicle on fresh acid potato.
	In broth indol produced in ten to twelve weeks.	On an average in three days. May be absent.
	In alkali-peptone broth by the fourth generation.	Within three days.
	In casein-peptone solution within five days.	Within three days.
	Weak acid production in litmus broth.	Strong acid production in litmus broth. (There are a few alkali producers.)
Biological, with serum of typhoid patient. (Widal Reaction).	Macroscopic.—Agglutination.	No agglutination.
	Microscopic.—Dilution 1 in 50 to 1 in 100; clumping.	No clumping. (A few coli, however, do clump.)
	Serum of typhoid, immunised animal protects against lethal dose.	No protection.

RESEMBLANCES.

They are alike in general size and shape, in cultural appearance in broth, on agar slope and plate, and on gelatine streak and plate. Owing to difference in rate of growth, the appearances are not similar as regards quantity after equal periods of cultivation.

On the whole the most reliable culture test is gas formation.

Description.—The usual *incubation period* is twelve to fourteen days, but this is subject to considerable variation, and it is possible that the longer or shorter time may depend on the method of introduction of the virus. In aerial infection the period of incubation is probably shorter than in alimental.

Symptoms.—The illness is insidious and prolonged, lasting, as a rule, three weeks before lysis leads to a lengthened convalescence. The fever is associated with intestinal ulceration, enlargement of the spleen, production of a typical "rose" rash appearing about the tenth day, characteristic temperature, and usually diarrhœa of a "pea-soup" nature. The so-called typhoid state derives its name from the peculiar affection of the central nervous system in enteric fever.

Types.—Abortive, ambulatory; infantile remittent, in which the disease is worse at one time of the day than at another; gastric or bilious, inflammatory, low nervous, irritative with hyperpyrexia, and hæmorrhagic.

Differential Diagnosis.—Distinguish from pneumonia, typhus fever, tubercular meningitis, general miliary tuberculosis, malaria, pyæmia, trichiniasis, ulcerative endocarditis, typhlitis, and at the outset of the fever from common bilious attacks.

Mortality.—The mortality is highest amongst infants and elderly people, least in children and young adults. The average case mortality in England is about 15 per cent.; in Scotland it is considerably lower.

Incidence.—*Age.*—The disease is primarily one of young adults, especially affecting males between the ages of 15 and 25. It is rare under the age of 2, and not very common in people over 40.

Sex.—Males are somewhat more liable than females.

Season.—The seasonal incidence of the disease is autumnal, and it may be very prevalent after a hot and dry summer.

Climate.—Meteorological conditions such as rainfall may increase or diminish the prevalence of the disease, according to the condition of the soil. As a moderately moist and polluted soil is favourable under certain temperature conditions to an outbreak of enteric, the rainfall may either bring the soil into a suitable condition for an outbreak, or may render it so moist as to be inimical to the inception and spread of the disease.

Recurrence.—One attack confers immunity which may be lifelong. On the other hand, the protection may be of the slightest, and one of us has known a case in South Africa in which a man suffered from two exceptionally severe attacks within a year. Women in pregnancy, after labour, and during lactation, are said to possess a certain degree of immunity, but this is not universally true.

Method of Transmission.—*Aerial.*—As the bacilli are present in the fæces, they may be conveyed by the dust of dried-up stools transported by wind, draughts, and dust-storms. The exhalations of defective drains are similarly infective, but it is not likely that those given off by fresh enteric stools can convey the disease.

Alimental.—Enteric fever is *par excellence* a water-borne disease. The bacillus may gain access to water supplies owing to their contamination with the excreta, since both fæces and urine may contain the specific organism in such a condition as to reproduce the disease. For example, a nurse has been known to contract the fever as a result of drinking out of a tumbler which, in a moment of emergency, had been previously used by an enteric patient as a urinal.

Further, the water supply may be polluted by emanations from excreta, as may occur when there is communication between a cistern and a defective soil-pipe; and an outbreak at Caius College, Cambridge, was caused by the sucking up of infected filth itself into the water service pipes.

Milk is a common vehicle for the conveyance of the poison. This may in part be due to the adulteration of the milk with infected water, but it may depend on contact of the milk with the exhalations from insanitary drains. Sometimes dirty dairy dishes and utensils may be to blame. The bacillus may be introduced through the medium of other food-stuffs, as when these become infected by flies or dust conveying the virus, or from the polluted hands of those in attendance on the patient. In addition, there is some evidence that cattle may suffer from a disease resembling enteric fever, and an epidemic has been attributed to the ingestion of the meat of animals thus infected. Oysters cultivated on beds to which sewage has access have been proved to convey typhoid. Other shell-fish, ice, ice-cream, celery, and water-cress have at various times been demonstrated to be the factors concerned. Outbreaks have also been traced to the ingestion of fried fish, which have become infected in the process of preparation as food.

Fomital.—Indirectly clothes, bedding, etc., may spread the disease if soiled by discharges. Contamination of linen, etc., has in several instances been attributed to infected mangles.

Direct corporeal.—The disease may be transmitted by infection through the mouth, from hands soiled by infected matter.

Indirect corporeal.—Flies and other insects undoubtedly play an important part as carriers of the bacillus, especially in military camps and hospitals during war and in a hot climate.

Briefly, the main method of transmission may be summed up in the words of Professor Wyllie, as being drains, dairies, drinking-water, and the dust of dried dejecta. Further, there may be added the filthy feet of fæcal-feeding flies.

Prevention.—*Of origin.*—General sanitary precautions to obviate the pollution of soil, water supplies, and food-stuffs, such as trapping, disconnection, and ventilation of drains and sewers, and the prevention of leakage from drains and cesspools. Oysters should not be grown on beds liable to become contaminated with sewage; but it has been proved that oysters which have taken up the specific organism will purify themselves if placed for one week in pure sea water. This should therefore be done in the case of all oysters coming from suspicious beds. Efficient cooking of food-stuffs, and, if necessary, the boiling of water and milk. Careful filtration of water through a Pasteur-Chamberland filter is efficient, but the process is slow, and unsuitable when dealing with large quantities of water. Schumberg's method for the sterilisation of water consists in adding 1 c.c. of a bromine solution to 5 litres of water, and after five minutes' contact neutralising with ammonia water. The bromine solution consists of 20 per cent. each of bromine and potassic bromide in water, the ammonia water is of the strength of 9 per cent. This process is stated to be capable of destroying the *B. typhosus* in water.

Other chemical methods have been devised, such as the addition of hypochlorite of lime, potassium permanganate, and tablets of sodium bisulphate

(Rideal) to the infected water. None of these procedures can be said to be reliable from a hygienic point of view.

It is probable that repeated inoculation with typhoid antitoxin, which consist of the dead bacilli and the products of bacillary growth in broth, lessens the liability to the attack, modifies the course of the fever, and diminishes its mortality. It is therefore advisable that persons likely to be exposed to infection should have inoculation performed. The immunity conferred by a single inoculation appears to be exhausted after from six to nine months.

Of spread.—Notification.—Isolation is certainly advisable, either at home or in special hospital wards. Inculcation of habits of cleanliness on those in attendance on the diseased. The use of a nail brush is essential.

The antiseptic cleansing of the perinæum and buttocks of the patient after each defæcation. A solution of 1 in 2000 corrosive sublimate with weak hydrochloric acid is a good application.

The disinfection by steam, dry heat, or by boiling, of all soiled clothing, bedding, etc., after a preliminary soaking in a 1 in 20 solution of carbolic acid. The protection of other patients and of food-stuffs from dust and flies, and the destruction of the latter.

Bed-pans should be cleansed with scalding water, and then with carbolic acid or other proper disinfectant.

Where possible, the disinfected or untreated excreta should be boiled for half an hour, or mixed with sawdust and cremated. In country places they may be buried, but not deeply, in spots far distant from houses, water supplies, or vegetable gardens. In towns and hospitals, disinfection must be enforced, and may be accomplished by means of boiling, steam, or by the addition of strong izal 5 per cent., or of mercuric chloride 1 in 500 along with hydrochloric acid to prevent the formation of the inert, insoluble albuminate of mercury; chinisol 1 in 600 is also good. Osler recommends a solution of carbolic acid 1 in 10, with contact for two to three hours, and, as a rough rule for the amount to be added, states that the stool should be completely covered by the solution. Thorough mixing of stool and disinfectant is essential, and disinfection of the stools should be continued for ten days after the temperature is normal. In cases of typhoid bacilluria it is necessary to likewise disinfect the urine, half its volume of 1 per cent. formalin being most useful. It must be remembered that whatever disinfectant be used, enough must be added to provide in the whole mixture sufficient disinfectant strength despite the dilution.

Baths used for typhoid patients should be disinfected with chloride of lime, one-half pound for each receptacle, and chlorinated lime is specially suitable for privies, trenches, the environs of hospital tents and army latrines. Izal has been found useful in South Africa as a deodorant and as preventing the settling of flies. House pipes and drains are probably best disinfected by the carbolic acid solution mentioned above kept in contact with them for several hours.

Sewage farms to which typhoid excreta have gained admission are best treated by adding slaked lime to the tanks and carriers.

As anything which shortens the illness or modifies its severity must be regarded as tending to prevent the spread of the disease, mention must be made of the new antityphoid extract of Jez, prepared from the organs, etc., of immunised rabbits, which is said to lessen the duration of the fever.

Erysipelas.

Syn., Rose.

Geographical Distribution.—World-wide; but more common in temperate regions.

Etiology.—The cause of the disease is the *Streptococcus erysipelatis* of Fehleisen. All cases, however, are not a pure infection, and other organisms may be present. It is probable that the streptococcus of erysipelas is merely a variety of the ordinary *Streptococcus pyogenes* (Plate III. Fig. 1).

Cultural Characteristics.—The streptococcus can be cultivated artificially, and when this is done in fluid media its chains may be of considerable length, though they tend to be short in the human body. On agar the growth consists of small, whitish grey, separate colonies. Gelatine is not liquefied.

Staining.—The ordinary anilin dyes are efficient, as is Gram's method.

Description.—The *incubation period* is from one to seven days.

Symptoms.—The onset is sudden, with rigors, pyrexia, and a spreading rash which has well-defined margins. The disease affects the skin, the cellular tissue, and mucous and serous membranes. It is common on the face and fauces, and in connection with wounds. The organism is found in the lymphatics, and extends along the line of the lymph vessels. There is desquamation on subsidence of the inflammation. Filth, overcrowding, defective ventilation, and previous attack predispose to the disease, which has also an obscure connection with diphtheritic outbreaks.

Types.—*Puerperal.*—It is noteworthy that women during the puerperium are peculiarly liable to erysipelas, which then develops in the cellular tissue of the pelvis, and is very fatal.

Other forms are migratory, phlegmonous, recurrent, and simple.

Differential Diagnosis.—Distinguish from anthrax, herpes of the face, erythema, dermatitis, and scarlatina.

Mortality.—The average case mortality is 4 to 7 per cent. The death-rate is greatest in drunkards and the aged. Erysipelas neonatorum is almost always fatal.

Incidence.—*Age.*—Children are specially liable.

Sex.—As noted, women in the puerperium are very susceptible.

Certain families are specially predisposed to the disease.

Season.—It is most prevalent in spring.

Climate.—The disease is common in years of deficient rainfall.

Recurrence.—One attack predisposes to a second.

Method of Transmission.—*Aerial.*—The poison clinging to particular wards in an hospital. The desquamating scales have not been known to convey the virus. Erysipelas is also *fomital*, *direct corporeal*, and *indirect corporeal*.

Prevention of Origin and Spread.—Notification.—Isolation until defervescence is established. Disinfection of fomites, hands, surgical instruments, sponges, etc. Protection of wounds and scratches liable to be infected. Medical men attending cases of erysipelas should on no account engage in midwifery practice, and no nurse who has recently come in contact with erysipelas should attend a confinement. The use of antiseptics has greatly tended to lessen the number of cases of puerperal erysipelas. The employment of curative serum obtained from animals which have been inoculated with intensified streptococcal cultures has not met with success, but has to be borne in mind.

"Fourth Disease."

Geographical Distribution.—So far the disease is only recognised in this country.

Etiology.—Unknown. It is only recently that the disease has been distinguished as a separate entity, and its very existence is still a matter for discussion. Its name is merely provisional, conferred upon it by Dr. Dukes, who first drew attention to the differences which he believes to exist between it and measles, rubeola, and scarlet fever. It is the "fourth" disease which more or less resembles the trio mentioned.

Description.—The *incubation period* seems to range from nine to twenty-one days.

Symptoms.—Put shortly, the fourth disease resembles a kind of scarlet fever variety of rubeola (German measles). In slight cases there are no premonitory symptoms. In severe cases there is headache and general malaise. The rash is usually what first attracts attention, and is bright rosy red, elevated and diffuse, covering the whole body. It is not so fiery to the touch as the rash of scarlet fever. Faucial and conjunctival catarrh are often present, and some glandular enlargement, mainly in the posterior cervical, axillary, and inguinal regions. Desquamation is not proportionate to the extent and severity of the rash, and may be almost absent in slight cases. The fever only lasts a few days, and sequelæ are practically unknown.

Differential Diagnosis.—Distinguish from rubeola and scarlet fever especially, and to a lesser extent from measles and the diseases likely to be confounded with the trio (*vide post*).

Mortality.—Recovery seems to be the invariable rule.

Incidence.—*Age.*—On children between the ages of 5 and 15.

Season.—Spring and summer.

Recurrence.—It seems to be protective against itself, but confers no immunity against measles, rubeola, or scarlet fever.

Isolation.—From fourteen to twenty-one days if disinfection has been thorough. Continued desquamation does not necessitate a prolongation of the period.

Quarantine.—Twenty-three days.

Method of Transmission.—As in rubeola (*vide post*). The fourth disease is probably not communicable during incubation, as are measles and rubeola. In this respect it is like scarlet fever.

Prevention of Origin and Spread.—Quarantine, isolation, disinfection. Notification may yet be essential if Dr. Dukes' observations are confirmed.

Morbilli.

Syn., Measles.

Geographical Distribution.—Universal; most common in urban districts.

Etiology.—Unknown; almost certainly due to a micro-organism which has not as yet been isolated.

Description.—The *incubation period* is from three to twenty days, usually ten days or a fortnight.

Symptoms.—It is a febrile disease characterised by a velvety rash occurring in adjacent, crescentic patches, originally and chiefly on the face and neck, and associated with catarrh of the mucous membrane of the eye, and of the respiratory and alimentary passages. It is followed by a branny, cutaneous desquamation. The fever runs a course of about a fortnight, and sequelæ are common.

Types.—Benign, malignant, hæmorrhagic, typhoidal.

Differential Diagnosis.—Distinguish from smallpox, typhus fever, scarlet fever, rubeola, the "fourth disease," dermatitis, and varicella.

Mortality.—The case mortality is small, about 3 per cent., but, owing to the extremely large number of cases, deaths from measles have a distinct effect upon the zymotic death-rate.

Incidence.—*Age.*—In this country measles is largely a disease of children, the majority of attacks occurring from the third to the fifth year, but it is attended with the greatest fatality in the second year of life. When introduced, however, into an isolated and hitherto immune community, its ravages affect all ages.

Sex.—The sexes are equally affected.

Season.—Measles is most common in June and December. As Dr. Claude Ker has suggested to us, it may be that the marked summer rise in "measles" is in part due to the prevalence of rubeola at that season. Epidemics vary much in virulence, several minor epidemics intervening between two severe outbreaks.

Recurrence.—One attack is usually protective for life, but by no means invariably so; in fact measles tends to recur more than any of the other exanthemata. Measles confers no protection against rubeola, or rubeola against measles.

Isolation has to be continued for three weeks or a month from the date of invasion.

Quarantine.—A fortnight or sixteen days.

Method of Transmission.—*Aerial.*—This is most important, owing to the fact that the disease is highly communicable before the symptoms are fully characteristic. Measles is also *fomital* and *direct corporeal.* Some believe that cats may play a part in transmitting the disease. We have seen cats suffering from catarrh and a form of mange during epidemics.

Prevention of Origin and Spread.—*Isolation.*—In this disease the value of isolation is not so marked as in some of the other exanthemata, since in measles seclusion of the patient is not possible sufficiently early to obviate the risk of spread. A further difficulty is the enormous number of cases to be dealt with if hospital isolation is to be efficiently carried out, necessitating great expense and an extension of existing hospital accommodation such as few local authorities can afford. Measles being popularly regarded as a trifling ailment, it is difficult to impress the public with the importance of segregating the sufferers. Again, the extreme youth of many of the patients causes reluctance on the part of parents to allow them to be sent to hospital.

Isolation, however, is highly desirable, and if applied to the earlier cases in an epidemic, might be expected to exercise a most beneficial influence on the extent of the outbreak.

Quarantine of contacts as far as possible.

Notification.—Measles is not included in the list of infectious diseases scheduled under the Infectious Diseases Notification Act, but in certain districts the local authorities have exercised their power of insisting on its notification. Other authorities would doubtless follow the same course, but are deterred by the number of notification fees which would have to be paid to medical men. Compulsory notification, like isolation, and for the same reasons, has proved of less value in checking measles than in other exanthemata. It has been given a lengthy trial in Edinburgh, and in some respects has proved a failure ; so much so, that Sir Henry Littlejohn, the medical officer of health, in his latest annual report has recommended that it be discontinued. Very often, however, it leads to an early discovery of scarlatinal cases simulating measles, and so proves of advantage indirectly. A great many mild cases are not seen by medical men at all, so that, if notification is to be of value, the householder's duty in this respect should be enforced. If it were possible, as has been suggested, to compel notification only in inter-epidemic periods and to isolate at the same time, certain epidemics might be prevented. The value of inhibiting an epidemic depends on the fact that it gives children time to pass the ages at which most attacks and the greatest fatality occur.

Inspection.—Thorough inspection of a district serves—(1) To ascertain the extent of the disease ; (2) to disclose unsuspected cases ; (3) to discover persons who have been exposed to infection, and to prevent their conveying the virus ; (4) to warn patients and guardians as to the prevalence and distribution of the disease ; (5) to prohibit healthy children from an infected house attending school. This inspection may be carried out by the sanitary inspector during the course of his routine duties, or, when necessary, a special staff may be appointed.

Closure of schools.—This precaution is only useful in the early stages of an epidemic, and the medical officer of health would do well to advise such a step only after careful consideration of — (*a*) The locality affected ; (*b*) the effect of school closure on the information he will receive regarding the outbreak ; (*c*) the opportunities for intercourse apart from school life. As a less drastic measure, the medical officer of health may arrange with the school authorities—(α) For a mutual interchange of information regarding sick children ; (β) to exclude scholars coming from infected houses ; (γ) to arrange with teachers so that they will warn him of any cases of coryza which they notice amongst their pupils ; (δ) to inform them when the epidemic is at an end.

General methods.—In addition to what has been described, information may be obtained from the officers of the Society for the Prevention of Cruelty to Children, if such exist, from district nurses, and from managers of crêches. Printed notices may be distributed describing symptoms and the precautions which must be taken. Finally, the medical officer of health should inform public libraries as to houses in which measles prevails.

Disinfection of buildings, fomites, and patient. In the last instance the value of baths must not be overlooked. Exclusion of cats from the sick-room. Burning of all rags used for wiping the eyes and nose or on which ear discharge is received. Destruction of sputa. Thorough ventilation and cleansing of infected premises both during and after the attack. Overcrowding in hospital wards is specially to be avoided, as under such conditions grave complications, such as broncho-pneumonia, are apt to ensue and become general.

Rubeola.

Syn., RUBELLA, RÖTHELN, GERMAN MEASLES, EPIDEMIC ROSEOLA, OR ROSE RASH.

GEOGRAPHICAL DISTRIBUTION.—Northern temperate climates; Egypt, India.

ETIOLOGY.—Unknown. No doubt due to a micro-organism.

DESCRIPTION.—The *incubation period* is on an average eighteen days, but varies from nine to twenty-two days.

SYMPTOMS.—Rubeola is a febrile disease with—(1) An early eruption of small pink papular spots beginning behind the ears and on the scalp and face, especially round the mouth. These latter change to a more general rash of a bright red colour. This rash may be entirely absent, or may closely resemble a scarlatiniform rash. (2) A glandular enlargement, especially of the posterior cervical, the axillary, and inguinal glands. (3) A catarrh of the throat, nose, and eyes, which, however, may be entirely absent. (4) A branny desquamation usually varying with the severity of the rash, but often absent.

TYPES.—Scarlatiniform, morbilliform. Aberrant forms are described which probably constitute a distinct disease (*vide* p. 20).

DIFFERENTIAL DIAGNOSIS.—Distinguish from measles, scarlet fever, the "fourth disease," roseola, erythema, the initial variolous rashes, and in the case of schoolboys from an erythematous condition produced by the handling of caterpillars.

MORTALITY.—The case mortality is very low, recovery being almost an invariable rule.

INCIDENCE.—*Age.*—It is primarily a disease of childhood, affecting children between 5 and 15, its incidence therefore being on older children than in the case of measles.

Sex.—Both sexes are equally affected.

Season.—It is most prevalent in spring and summer in this country.

RECURRENCE.—Second attacks are rare.

QUARANTINE.—Should extend to twenty-three days.

ISOLATION.—Should extend to twenty-one days from the beginning of the attack. It need not be practised after the third week, even if all desquamation has not ceased, provided proper precautions have been taken.

METHOD OF TRANSMISSION.—The disease is communicable directly from one person to another, but the precise mode of conveyance of the virus is unknown.

PREVENTION OF ORIGIN AND SPREAD.—*Isolation.*—It must be noted here also that the disease is communicable before the characteristic symptoms appear. Quarantine, disinfection, and notification as in measles.

Scarlet Fever.

Syn., Scarlatina.

Geographical Distribution.—Essentially European, but has spread from Europe to North and South America and even to Australia. It is rare in Africa and Asia, with the exception of Asia Minor, and is unknown in Japan. The fever is most common in urban districts.

Etiology.—Various micro-organisms have been described, amongst them the *Streptococcus scarlatinæ* of Klein or *Streptococcus conglomeratus* of Kürth. The streptococcus has been found in the tonsillar and faucial secretions and in the blood during life. It has also been obtained from the udder sores of cows in a dairy to which was traced a milk-spread epidemic of scarlet fever. It has not been found in the urine, but has been discovered in the blood, bone-marrow, and viscera post-mortem. In twenty-one acute cases, the blood from which was examined during life by one of us (A. B.), this organism was only present in a solitary instance (Plate III. Fig. 2). In sixteen acute cases, the urine of which was examined by one of us (C. L.), this organism was absent; but in seven of the cases, streptococci were found in the urine, one species in two cases and another in five cases.

Baginsky and Sömmerfeld have described another streptococcus present in the throat, blood, spinal fluid, and urine during life, and in the bone-marrow and viscera of every one of forty-two fatal cases.

A streptococcus, having the same cultural characteristics as this organism, was present in the urine in two of the sixteen cases referred to above.

Class of Chicago has described a streptococcus found in the desquamated skin scales, blood, and throat. It produces a disease resembling scarlatina when injected into white swine.

The real cause of the fever cannot as yet be said to be definitely known; but the bulk of the evidence is strongly in favour of scarlet fever being a streptococcal disease, the pleomorphic characters of the streptococcal group rendering it possible that all these observers are describing the same organism under different conditions of environment.

Description. — The *incubation period* is usually twenty-four hours. Extreme limits, twelve hours to seven days.

Symptoms.—Scarlatina is an acute febrile disease with a sudden onset marked by sore throat, headache, and vomiting. A rash appears about twenty-four hours after the onset. It is red and punctate at first, but rapidly becomes diffuse, commencing on the neck and chest, and spreading over the whole cutaneous surface; affecting also mucous membranes, especially that of the fauces. About the end of a week the fever usually abates and desquamation sets in, continuing five to seven weeks, the hands and feet being the last parts to clear. The fever is often complicated by suppurative otitis and rhinitis, while true relapses sometimes occur.

Types.—Rudimentary, simplex, anginosa, maligna.

Differential Diagnosis. — Distinguish from tonsillitis, diphtheria, measles, the "fourth disease," rubeola, erysipelas, early smallpox, erythema, influenza, eczema and dry rashes, septicæmia, and acute exfoliating dermatitis.

Mortality.—The case mortality varies in different epidemics, and is more severe during the early part of an epidemic. Except in children under 5, the mortality is about 5 per cent. Below that age it is three to four times as great.

Incidence.—*Age.*—1 to 10 years especially. Infants and adults less susceptible.

Sex.—It is slightly greater on females.

Season.—It is most prevalent in October in Europe, but this does not hold good in other parts of the world. Like erysipelas, it is most common in dry, hot years.

Recurrence.—One attack generally confers immunity for life, but second attacks are known to have occurred, especially after a long interval; while, as already stated, relapses may take place after a short interval.

Isolation in the early stages of scarlet fever is much more effectual in arresting the transmission than isolation at a similar stage in measles. It must be continued till all traces of desquamation have vanished, and till all discharges have ceased. Otherwise, what are known as "return" cases will crop up, that is, cases occurring amongst the members of the household with whom the patient mingles when his period of insufficient isolation is at an end.

Quarantine.—One week.

Method of Transmission.—*Aerial*, mainly by inhalation of the breath or desiccated discharges or minute scales, but the disease is not usually conveyed by aerial connection through districts surrounding fever hospitals.

Alimental, as from an infected milk supply. Milk may be infected from the desquamation or discharges of human beings suffering from the disease.

Further, a disease analogous to scarlet fever is known to affect cows, causing loss of hair and a vesicular eruption on the teats and udders, the vesicles becoming ulcers. Milk taken from cows in this condition has undoubtedly produced an epidemic of scarlet fever. This was first discovered in the classical Hendon outbreak.

The characteristics of a "milk" epidemic of scarlet fever are—(1) Sudden onset; (2) rapid decline; (3) simultaneous attacks; (4) mild type. Scarlet fever is not known to have been transmitted through the agency of water or other food-stuffs apart from milk.

Fomital, a most important mode, owing to the persistence with which the virus clings to infected articles even through a period of years. This is especially the case when it is favoured by stagnant air, darkness, and no extremes of temperature.

Direct corporeal, as from immediate transmission of the poison from man to man. Abrasions of the skin are peculiarly liable to absorb the virus, as is also the genital tract of puerperal women. Desquamated scales and discharges may be the medium of thus directly transmitting the disease, while, if the virus be excreted in the urine, this source of infection must not be overlooked. Further, if animals, such as cows, do suffer from scarlet fever, it is conceivable that the disease might be directly transmitted to those in contact with them.

Indirect corporeal.—Scarlet fever is very easily conveyed in this manner through the medium of man. It is of special importance in the case of puerperal women. These should never be attended by a doctor or nurse who has recently been exposed to infection. The disease may possibly be carried by domestic animals, such as dogs and cats.

Prevention of Origin and Spread.—Isolation; notification; quarantine. Closure of schools, or exclusion of scholars. The former method may have to be carried out, but not so frequently as in measles if the latter alternative be properly put in force. Inspection and advice to persons concerned. During epidemics, heads of families should be informed as to the advisability of sterilising milk by boiling. Stoppage of milk supplies from suspected farms and dairies.

General methods include disinfection of buildings, fomites, contacts, discharges, and the patient. All infected rags should be burned. Again, the value of baths must be insisted upon, while inunction to prevent the dissemination of scales is of great importance.

Syphilis.

Geographical Distribution.—World-wide; more prevalent in some countries than in others.

Etiology.—A bacillus has been described, but its causal connection with the disease has not yet been proved.

Description.—Syphilis is peculiar to man, being unknown amongst the lower animals. Its *incubation period* is three weeks.

Symptoms.—After a period of incubation lasting three weeks, or it may be longer, the *primary lesion* develops at the seat of inoculation, with consequent enlargement of the lymphatic glands connected with the lymph vessels leading from the part.

A *secondary stage* commences six weeks later, and commonly lasts two years, characterised at first by a typical rash on the chest and abdomen, with sore throat and faucial inflammation, and later by loss of hair, polymorphous coppery eruptions of the skin in various parts of the body, but affecting chiefly the flexor surfaces, iritis and choroiditis, and glandular swellings. Then comes a latent period of uncertain length, followed by a *tertiary stage*, commencing two to ten years after the primary sore, and characterised by lesions of the skin, mucous membranes, bones, and internal organs. Gummata, waxy disease, locomotor ataxia, and paralysis may occur at this stage, which often lasts for many years.

Types.—Congenital and acquired.

Differential Diagnosis.—Distinguish the rash from measles and scarlet fever, and skin diseases due to other causes.

Mortality.—Congenital syphilis is very fatal to child life. The acquired form is rarely directly fatal, but its tertiary lesions frequently tend to shorten life.

Incidence.—*Age.*—All ages are liable. It is most common in young adults.

Sex.—Both sexes are liable, but chiefly males.

Season.—There is no special seasonal incidence in this country; but its ravages are worse during the hot season amongst Europeans living in the tropics.

Recurrence.—One attack confers immunity during the primary and secondary stages and for some time thereafter, but is not lifelong.

Method of Transmission.—*Fomital.*—*Direct corporeal*, as from sexual congress or other means, such as wound infection, kissing, etc. In such cases there is usually a wound or abrasion of the skin or the mucous membrane. The milk secretion, tears, sweat, and semen are stated to be innocuous, as is the saliva if the mouth be healthy.

Indirect corporeal, as when the disease is transmitted to the mother from a fœtus infected by the father, or when the healthy fœtus acquires syphilis from a mother infected during the period of pregnancy.

Syphilis is hereditary, and though in its typical form it is not transmitted to the third generation, yet individuals in this generation are susceptible to certain forms of disease which are in all probability connected with the syphilitic infection of antecedent generations.

Prevention of Origin and Spread.—From a public health point of view, and taking into consideration the large number of innocent people at risk, there can be no doubt that the inspection and licensing of prostitutes is a valuable help in preventing both the origin and spread of syphilis. The wilful exposure of persons suffering from infectious disease is punishable by law, and it is strange that a public plague like syphilis, whose effects on the population are infinitely worse than those of any infectious disease, should not lie under like restrictions.

There are no public regulations as to the marriage of syphilitics, but it is highly desirable that such should not marry within two years of the last appearance of any syphilitic symptom, and certainly not within two years from the date of the primary lesion.

Minor aids are to be found in taking proper sanitary precautions as regards the condition of public conveniences.

Typhus Fever.

Syn., Jail Fever.

Geographical Distribution.—It is endemic in Great Britain, Ireland, and Russia; epidemic in most countries situated in the temperate zone, but rare in the tropics. Typhus fever is a disease of towns, and was wont to follow in the track of armies.

Etiology.—Several varieties of organism have been described, the latest a diplococcus found by Balfour and Porter in the blood of a large number of cases, both during life and post-mortem (Plate III. Fig. 3 and Fig. 6). There is no absolute proof that the fever owes its origin to any of those.

Description. — The disease does not affect the lower animals. The average *incubation period* is twelve days.

Symptoms.—Typhus is a continued fever lasting fourteen days, and characterised by a sudden onset, with severe frontal headache, rigors, and, it may be, vomiting. The typical diffuse mulberry rash appears on the fourth or fifth day, usually commencing about the anterior folds of the axillæ, the backs of the hands, and the elbows. The fever is associated with marked nervous symptoms, and a peculiar odour of the body, variously described as being like that of damp straw, mice, etc. It terminates by crisis about the fourteenth day if recovery is to take place. Otherwise, the fever is prolonged, and the symptoms do not abate. The disease may terminate fatally before the fourteenth day.

Fig. 6.—Diplococcus found in typhus; liquefaction in jelly stab culture.

Types.—Abortive, most common in children. In such cases there may only be a slight rise of temperature, lasting perhaps only a day or two, with a very transient rash, and few, if any, of the typical symptoms. Hæmorrhagic, catarrhal, malignant, adynamic, ataxic.

Differential Diagnosis.—Distinguish from enteric fever, relapsing fever, remittent fever, purpura, measles, cerebro-spinal fever, delirium tremens, pneumonia, uræmia, and meningitis.

Mortality.—The case mortality increases with age above 30. It is greater amongst males, especially alcoholics, and it is worthy of note that the fever is more severe in those with educated brains and highly developed nervous systems. The mortality varies with the epidemic, but is usually from 10 per cent. to 20 per cent., being greatest during the early part of an epidemic.

Incidence.—*Age.*—Those from 10 to 20 years are most susceptible to attack, and the fever is rare over 50.

Sex.—It shows no marked predilection for either sex.

Season.—Typhus in this country is more prevalent in the winter, owing to the fact that there is then more overcrowding in houses and less ventilation.

Recurrence.—One attack usually confers lifelong immunity, but this is probably not so often the case as is generally supposed.

Isolation has to be continued for five weeks after the onset.

Quarantine.—Fourteen to sixteen days.

Method of Transmission.—*Aerial.*—This is the main method, though the "striking distance" of typhus is not great, owing to the detrimental effects of air and sunlight upon the virus. The poison is given off by the breath and skin, and possibly, though not probably, by the evacuations.

Fomital.—The virus may be conveyed by clothes, bedding, etc., and especially by dark-coloured woollen articles of dress.

Telluric.—It is quite possible that the persistent way in which typhus hangs for years about a certain locality, such as a court or close, is dependent upon the virus having a habitat in the soil, or at least amongst the dust and refuse found in low-class houses. Should this be the case, its transmission to the individual would almost certainly be by means of air, as there is no evidence that the disease is inoculable, or can be conveyed by food or water.

Direct corporeal.—The body of a person dead of typhus is extremely apt to convey the infection, even more so than that of a living patient.

Prevention of Origin and Spread. — Notification; Isolation.—This, if at all possible, should be carried out in hospital.

Quarantine is of extreme importance. All persons who have been in any way exposed to infection should be removed to some convenient house of reception, and kept there under close observation for a period of from fourteen to sixteen days. In case of death, "waking" of the corpse must be prohibited, and the cadaver should be wrapped in a sheet previously soaked in 1 in 500 solution of perchloride of mercury.

General Methods.—By far the most important is efficient ventilation. To prevent outbreaks, good food, fresh air, temperance, and the avoidance of overcrowding are essential. Indeed, it may be said that dirt, darkness, drink, and destitution disseminate typhus fever.

Old dwellings in endemic localities should be pulled down, and occupation of one-roomed houses prohibited. Local authorities should be advised of the provisions of the Housing of the Working Classes Act, which enables them

Plate III.

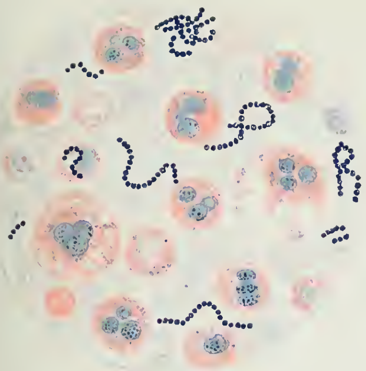


Fig 1

Fig 2

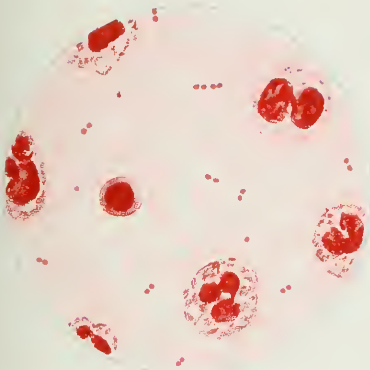


Fig 3

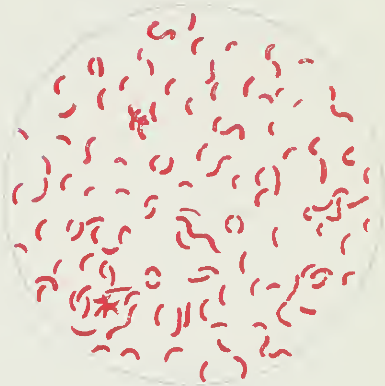


Fig 4

Fig 5.

Fig 6

Figure 1.—*Erysipelas, Streptococcus Pyogenes* in pus, *Empyema* (× 1000 diam.). Eosin and meth. blue.
„ 2.—*Streptococci*, scarlet fever case (× 1000 diam.). Carbol. fuchsin.
„ 3.—*Typhus Fever*, Diplococcus, from splenic pulp (× 1000 diam.). Carbol fuchsin.
„ 4.—*Cholera Spirillum*, 24 hours' agar culture (× 1000 diam.). Carbol fuchsin.
„ 5.—*Cholera Spirillum*, 12 hours agar culture, showing flagella (× 1000 diam.) Muir's flagella stain.
„ 6.—*Bacillus Diphtheriæ* (*a*) 12 hours culture (short form) (× 1000 diam.). Neisser's stain.
(*b*) Film from swab (long form) with streptococci (× 1000 diam.). Eos. and meth. blue.

to deal efficiently with the insanitary areas in which the poison of typhus loves to lurk.

In the hospital treatment of the fever, both the windows and door or doors of the ward should remain constantly open, some volatile disinfectant should be employed, and the patients should have very few bedclothes during the acute stage, a single blanket sufficing. The beds must be kept farther apart than is the practice in treating most other fevers, and each patient requires a larger air space than usual, namely, 3000 cubic feet.

Disinfection of buildings, fomites, discharges, patients, and contacts. All rags used by patients should be burned, and it is a good plan to sponge the patients with Jeyes' fluid, thereby obviating in large measure the disagreeable typhus odour.

Varicella.

Syn., Chickenpox.

Geographical Distribution.—It is most frequent in countries with temperate climates.

Etiology.—Micro-organisms have been described as present both in the blood and the vesicular fluid, but the pathogenetic virus cannot be said to have been identified.

Description.—Chickenpox is an epidemic disease unknown in the lower animals. The *incubation period* is eleven to nineteen days, commonly a fortnight.

Symptoms.—There may be a few initial symptoms, such as fretfulness and fever, but the chief manifestation is a vesicular eruption affecting both the skin and the mucous membranes, beginning as red papules on the second day of the fever, and appearing in successive crops for several successive days. They are most profuse ont he back and shoulders. The vesicles, which are unilocular and globular in shape, become somewhat opaque, and form crusts, which drop off, leaving little or no scar.

Types.—Simple, gangrenous, hæmorrhagic.

Differential Diagnosis.—Distinguish from smallpox, acne, vesicular and pustular syphilitic eruptions, herpes, lichen, pemphigus, and a few less common skin affections.

Mortality.—Practically nil, except in unhealthy children.

Incidence.—*Age.*—The maximum number of cases occurs between the ages of 3 and 4. Infants are affected, adults rarely.

Sex.—Both sexes are equally liable.

Season.—It is probably most common in the autumn.

Recurrence.—One attack usually protects for life, but second and even third attacks have been recorded.

Isolation is to be continued till all the scabs have dropped off, usually for three or four weeks from the onset.

Quarantine.—Eighteen to twenty-one days.

Method of Transmission.—*Aerial*, *fomital*, *direct corporeal*, also *indirect corporeal*, as when conveyed by a third person handling the sick.

The following well-authenticated case gives rise to the question, can chickenpox be transmitted to the child in utero? An infant exhibited the typical vesicular eruption the day after its birth. The mother had no sign of chickenpox, but six other children in the house were suffering from the disease. It is therefore apparent, if the diagnosis was correct, that the infant contracted the disease in utero, or the incubation period can only have been one day.

Prevention of Origin and Spread.—Notification, though it is not compulsory. Quarantine, isolation, disinfection of buildings, fomites, and patients. Skin inunction to prevent dissemination of crusts.

Variola.

Syn., Smallpox.

Geographical Distribution.—The disease is endemic in India and the Soudan, and to a less extent in London. It spreads as epidemics to all parts of the world, and may become pandemic.

Etiology.—As yet unknown; possibly a spore-forming bacillus described independently by Klein and Bay.

Description.—Smallpox is an eruptive fever which can be transferred from men to animals, while possibly cowpox in cattle, and one of the forms of "grease" in horses, are identical with variola.

The *stage of incubation* lasts from eleven to fourteen days, and is followed by *prodromal symptoms*, such as headache, pain in the back, rigors, sickness, and, it may be, convulsions. There is also a rise in temperature, and there may be initial rashes of two kinds—erythematous, like scarlet fever or measles, and hæmorrhagic. These rashes are to be looked for on the inner sides of the thighs and on the lower part of the abdomen, where the area affected is of the shape of a triangle. Then comes the stage of characteristic eruption, which, as a rule, appears forty-eight hours after the initial symptoms, and lasts from four to five days. It commences in the form of macules, which change to small, red, itchy papules of a shotty hardness, and appear first on the face and wrists, quickly becoming general.

After two days these papules become vesicular, the vesicles being of the size of peas, and at first umbilicated. They pass into the stage of maturation when suppuration takes place in the vesicles, and there is inflammation round about them, with marked increase of temperature. Finally, the pocks dry up and crusts form, which eventually drop off, leaving cicatrices more or less depressed. The eruption affects mucous membrane, especially that of the mouth and throat, and the fever persists, as a rule, for about a fortnight.

Modified smallpox, or *Varioloid*, which is variola altered by previous inoculation or vaccination of the patient, differs from the typical fever in the fact that, after an initial stage analogous to, but milder than, the ordinary form, the eruption passes through its various phases much more quickly, that macules and umbilication of the vesicles may be absent altogether, while papules may abort without ever becoming vesicles. The constitutional symptoms are very mild, and the temperature may be but a little above normal after the appearance of the eruption. The whole duration of the disease is much curtailed, there may be no eruption whatever, and complications are usually absent.

Types.—Discrete, confluent, hæmorrhagic or malignant.

Differential Diagnosis.—Distinguish from chickenpox, scarlet fever, measles, rubeola, typhus, influenza, glanders, and cerebro-spinal fever. Also from various forms of skin eruption.

Mortality.—The average of statistics taken from six recent epidemics is 35·4 per cent. in the unvaccinated, and only 5·2 per cent. in the vaccinated. It is about 1 per cent. more fatal to males than to females.

Incidence.—*Age.*—Smallpox was originally a disease of children, then it became a disease of unvaccinated adults. This character it still retains in well-vaccinated communities, but in places where vaccination has fallen into disuse, it is steadily tending to revert to its former type.

Sex.—Nowadays males are more exposed to infection than females.

Season.—It is most prevalent in spring and winter.

Race.—The black races are especially prone to smallpox in a very deadly form.

Recurrence.—Second and even third attacks have been known, but are not common.

Isolation.—Till all the crusts have dropped off, usually six weeks from the onset.

Quarantine.—Seventeen days.

Method of Transmission.—*Aerial.*—This is very important, as the virus can be conveyed long distances, so much so that cases have been found to radiate from smallpox hospitals, the proportion of invaded houses diminishing as the distance from the hospital increased. The direction of prevailing winds has been known to determine the tendency of spread. Such transmission is most common when the cases are acute.

Fomital.—*Direct corporeal*, as in typhus, the cadaver being specially liable to transmit the disease. *Indirect corporeal.*

Prevention of Origin and Spread.—Notification.—Isolation in hospitals remote from population. House to house inspection. Disinfection of buildings, fomites (rags should be burned), patients, and contacts, and inunction of the skin to prevent dissemination of crusts. In the case of death occurring, the body should be wrapped in a sheet which has been previously soaked in a 1 in 500 solution of corrosive sublimate; "waking" of the corpse must be prohibited, the funeral should be private, and cremation should be advised.

Vaccination and revaccination of the whole population not recently protected, and revaccination of cases of suspected infection. As the incubation of vaccinia is considerably shorter than that of variola, it is possible by vaccinating a person after his exposure to infection to arrest and modify the disease. If done within three days it will prevent the attack, if within six days it will modify it. This is even more true of revaccination than of vaccination. The question of vaccination is discussed, p. 283.

OTHER COMMUNICABLE DISEASES.

Beri-beri.

Syn., Epidemic Multiple Peripheral Neuritis.

Geographical Distribution. — Its natural habitat is in tropical and subtropical regions, where it is for the most part endemic. It is found chiefly in the islands of the Malay Archipelago, but is common in Japan, the region of the Congo, Brazil, Central America, etc. It occurs in Australia and Fiji, and used to be frequent in India. There have been occasional cases in this country, and even a considerable outbreak at an asylum in Ireland, while other countries in temperate latitudes are not exempt.

Etiology.—Beri-beri is undoubtedly a germ disease, but the specific virus has not as yet been isolated. The symptoms are probably due to the absorption of a product of the organism rather than the organism itself. The blood of beri-beries has been found to contain a toxine which is a cardiac depressant, and resembles choline in composition. A minute fungus found in rice has been supposed to be the cause, and a motile micrococcus discovered in the blood of patients has been described. The subject is at present under investigation by a special expedition.

Description.—The disease is unknown in the lower animals. The *incubation period* is prolonged, being rarely less than one month.

Symptoms.—The onset may be either rapid or slow, and the disease may run a short or prolonged course, *i.e.* a few days or many months. The legs are primarily affected, there being œdema, muscular weakness, and hyperæsthesia or numbness. The œdema and numbness are chiefly present over the front of the shins. There is palpitation and cardiac dilatation which may end in sudden death, and vomiting is of serious import.

Types.—Dropsical or wet beri-beri; paralytic, atrophic, or dry beri-beri; mixed forms; pernicious; larval or rudimentary.

Differential Diagnosis.—Distinguish from peripheral neuritis (especially alcoholic or arsenical), rheumatism, malaria, epidemic dropsy, paresis and œdematous conditions due to other causes.

Mortality.—5 to 30 per cent. or even more. It is higher in some epidemics than in others, also in low than in high latitudes, in the dropsical than in the atrophic form, in the acute variety than in the chronic.

Incidence—Age.—It specially affects persons between 15 and 30, but all ages are liable save infants and the very old.

Sex.—There is an equal liability, and it is apt to attack pregnant women.

Season.—It is worst in the hot part of the year, whether occurring in temperate or tropical climates.

Race.—It principally affects the black and yellow races, but is not confined to them.

Recurrence.—One attack does not render immune.

Isolation and Quarantine.—It is probable that beri-beri does not spread from man to man, so that these methods are of no avail.

Method of Transmission. — *Aerial.*—The invasion being probably dependent, as stated, on the absorption of the toxine of an organism existing in the soil, or clinging to infected buildings or other places, such as ships' forecastles.

Alimental.—It is possible that the toxine may affect food, such as rice, certain forms of fish, etc., but there is no direct proof of this method of transmission. The experience of the Japanese navy, however, favours the idea that food may be the cause, since beri-beri has diminished greatly among the seamen since their diet was made more nitrogenous and the use of raw fish abolished. The eating of shelled rice is, in Japan, supposed to produce the disease.

Telluric.—The connection of the disease with the soil has already been mentioned. There is no proof of an actual conveyance by soil or dust.

Prevention of Origin and Spread.—Removal of the patient from the infected place, be it building, ship, or camp, and, if possible, from the endemic district. Disinfection of infected places, and in ships, removal of the bilge-water and all rotting wood, with thorough disinfection, ventilation, and cleansing. Both ships and institutions, if infected, should be deserted until proper sanitary methods have been employed.

General methods include avoidance of overcrowding and damp, ventilation especially of floor space and sleeping apartments, the free admission of sun-light, good food rich in nitrogen, a dry locality, and a sleeping-place raised from the ground, if possible in an upper storey.

Cholera.

Geographical Distribution.—Cholera is endemic in Lower Bengal, especially in the delta of the Ganges, northern Persia, and other Eastern countries. It spreads as an epidemic from these parts along the lines of traffic, and may become pandemic. European invasion occurs along three main routes:—(*a*) *viâ* Afghanistan, Persia, the Caspian, and the valley of the Volga; (*b*) *viâ* the Persian Gulf, Syria, Asia Minor, Turkey, and the Mediterranean; (*c*) *viâ* the Red Sea, Egypt, and the Mediterranean. Well-nigh every country not isolated from human intercourse has at one time or other harboured cholera, but the disease has not as yet invaded Cape Colony, Australia, New Zealand, Iceland, the Orkneys, and various islands of the sea.

Etiology.—Cholera is associated with the presence of the comma bacillus or cholera spirillum in the intestinal contents of patients suffering from the disease. This organism, however, though present in every true case of cholera, has not yet been proved to be the sole exciting cause, as the disease has never been reproduced in man or the lower animals by administration of the vibrio, except in two instances of laboratory infection and in the case of the *Spermophilus guttatus* (ground squirrel).

The cholera spirilla, as found in the intestinal contents and the adjacent mucous membrane, are small organisms curved in one direction, and hence resembling commas, mostly single, but they may be attached end to end, giving the appearance of the letter S (Plate III. Fig. 4). In culture, longer forms occur, while in film preparations from the intestinal contents the spirilla with their long axes arranged in one direction resemble fish heading up a stream. The bacillus is extremely motile, and, after appropriate staining, flagella can be discerned, each organism usually possessing a single long flagellum terminally placed (Plate III. Fig. 5).

Cultural Characteristics.—The favourite temperature is 37° C., but growth will take place at ordinary room temperature, except on potato. The culture on agar, blood serum, and in peptone gelatine is greyish white. Gelatine and blood serum are liquefied, while on gelatine plates there is the characteristic "silver sand" sprinkling, each colony producing liquefaction. Apart from colour, the appearance in jelly stab is shown in Fig. 7. On potato a brownish growth like that of the *B. mallei* is forthcoming. In broth there is a general turbidity with pellicle formation on the surface. The bacillus grows in milk without producing coagulation. In all media the growth is very rapid. In peptone solutions the spirillum forms indol within twenty-four hours at 37° C., and the red indol reaction can then be obtained by the addition of sulphuric acid alone, the growth of the organism having resulted in nitrite formation. Aerobic conditions are much more favourable to growth and development than anaerobic.

Staining.—The bacillus stains easily, especially with methylene-blue and weak carbol-fuchsin, but does not retain the stain in Gram's method.

Description.—The *incubation period* varies from a few hours to ten days. On an average it is three to six days.

Symptoms.—There may or may not be prodromal symptoms, such as cramps and diarrhœa. The disease commences with profuse diarrhœa, at first fæcal, and later the typical rice-water stool containing numerous shreds, which pours from the patient till his body is drained of fluid. Vomiting and severe cramps supervene, the vomited matter being at first the food, latterly the same rice-water material that is passed by the bowel. The loss of fluid produces the shrunken aspect of the cholera-stricken patient. Collapse may ensue, the surface temperature being below, while that of the rectum is above normal. The algid stage may end in death, recovery, or febrile reaction, but the disease may terminate fatally in a few hours.

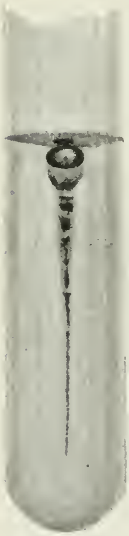


Fig. 7.—Culture of *V. choleræ* in gelatine; one week old growth.

Types.—Ambulatory, cholerine, cholera sicca, typhoidal (in later stages).

Differential Diagnosis.—Distinguish from diarrhœa, dysentery, cholera nostras, mushroom and ptomaine poisoning, early trichinosis, pernicious malaria, arsenical and corrosive sublimate poisoning.

Mortality.—The early cases of an epidemic are the most fatal, and epidemics themselves vary in severity. The average case mortality is 50 per cent.; it is greater in females up to 25 years, thereafter in males.

Incidence.—*Age.*—No special preference.

Sex.—Both sexes are equally liable.

Season.—The time at which the soil, polluted by organic matter and containing the specific organism, is moderately moist, well aerated, and warm, is the time at which cholera attains its maximum prevalence (see p. 179).

Race.—Cholera is more common among, and more fatal to, negroes than Europeans. European settlers in hot countries, however, suffer more than the natives.

Recurrence.—One attack does not protect against a second, though it does not render the patient more liable to the disease.

Isolation is to be continued till recovery has taken place.

Quarantine must be for ten days.

Method of Transmission.—*Aerial, alimental, fomital, direct corporeal, indirect corporeal.*

Cholera is transmitted by man's manifold motions. It never travels faster than a man can travel, and is spread by human intercourse between places far apart, such as occurs during pilgrimages.

Aerial, such as occurs by the inhalation of the dust of dried choleraic dejecta or inspissated vomit. It is to be noted, however, that the vibrios rapidly die when dried, though they grow in sunlight and the X-rays.

Alimental, as from water. Cholera, like enteric fever, is essentially water-borne, a contaminated water supply spreading the disease over its area of distribution. Klein found that in well, lake, and rain waters cholera vibrios were much more resistant than typhoid bacilli. Other foods, such as milk and vegetables, may be infected from the water, or more rarely by other methods.

Fomital, as in the case of soiled rags, etc.

Direct corporeal, as in enteric.

Indirect corporeal, as through the agency of flies contaminating food supplies.

Prevention of Origin and Spread.—Notification.—Isolation of cholera patients from other persons, to obviate the risk of infection from the discharges. It is obvious that it cannot be wise to treat cases of cholera in the same wards with patients suffering from such diseases as diarrhœa, dysentery, and enteric fever. Quarantine of persons who have been exposed to the risk of infection. As an example, consider the case of a vessel with cholera on board arriving at a British seaport. What is the duty of the medical officer of health? Besides taking the sanitary precautions to be stated in their proper place, he must detain any persons suspected of having the disease for a period not exceeding two days, to satisfy himself whether their illness is or is not cholera. Further, no person is allowed to leave the ship till he has informed the medical officer of health of his name, destination, and address at such destination; and the medical officer of health, through the proper channel, must notify the medical officer of health of the district of destination that such a person is proceeding thither (see Cholera Orders, p. 537). Under other conditions quarantine has not justified its enforcement, and good sanitation is infinitely more important.

Disposal of the dead.—In such a case as that cited above, if a death occurs on board, the medical officer of health must advise the sanitary authority as to whether they should direct the shipmaster to bury the body out at sea properly weighted, or to deliver it to themselves for interment. In the latter instance cremation would be the better method of disposal.

During the existence of cholera in foreign countries, the importation of rags from infected ports may be prohibited, or the rags may be landed for burning or disinfection by steam. In the case of camps and pilgrims, etc., any suspicious water supply must be condemned, or, failing this, all water and milk must be boiled before use. Infected fomites must be burned, and choleraic stools should be boiled or mixed with sawdust and cremated. Flies and other insects should be destroyed as much as possible, and their access to food and water prevented.

The use of lime has been strongly advocated in Germany for the disinfection of sewage farms and the bilge of ships, a strongly alkaline reaction being the test that sufficient milk of lime has been added. Water pipes may be disinfected by pumping 3 per cent. carbolic acid solution into them, allowing it to remain in them for twenty-four hours, and then flushing them out with pure water.

General Methods.—When cholera is imminent, special attention should be directed to the cleanliness of the threatened district, the general health of the inhabitants, the purity of the water supply, the condition of filters and water service pipes, the state of drains, sewers, and all public conveniences, the facilities for refuse and filth removal, etc.

If cholera appears, depôts should be established where astringent and other medicines can be dispensed gratis, and information given regarding the disease and its predisposing causes, such as chill, intemperance, overwork, and injudicious feeding. Ample hospital accommodation and a sufficient nursing staff must be provided, while "waking" of the dead is to be strictly prohibited.

All drinking-water, milk, and water used for cleansing food utensils should be boiled. Reliance should not be placed on filters or the treatment of water by permanganate of potash. Disinfection of buildings, fomites, discharges, and wells. The Prussian Government Sanitary Institution recommends the use of calcium hydrate and chlorinated lime for the disinfection of cholera dejecta.

Equal parts of fresh quicklime and water are added together so as to slake the lime, which is then diluted with three times as much water as has been previously used. Equal quantities of this mixture and cholera dejecta are thoroughly stirred together and allowed to stand for an hour, when all the vibrios are killed.

Chlorinated lime is employed as a powder, from one to two tablespoonfuls being added to one pint of cholera dejecta. Twenty minutes suffices for complete disinfection.

Special Prophylaxis.—An attempt to secure immunity is practised by Haffkine in India. It consists in the injection of living cultures of the cholera bacillus, at first in an attenuated condition, and then with exalted virulence. Carbolised cultures have also been employed, the effect being here produced by the bacillary products.

Diarrhœa Epidemica.

Syn., Epidemic or Zymotic Enteritis.

Geographical Distribution.—It is endemic in insanitary towns situated on polluted soil of a loose porous nature. It is epidemic at certain seasons.

Etiology.—The disease is probably caused by a poison produced by an unknown organism which has its habitat in polluted and suitable soil, the virus being absorbed by milk and other food-stuffs. It is also possible that, should the organism gain admission to the food itself, it may therein produce the poison.

Description.—The *incubation period* varies from a few hours to two days.

Symptoms.—The leading phenomenon is the epidemic character of a diarrhœa, more fatal than ordinary diarrhœa, which may be accompanied by vomiting and convulsions with a lessened excretion of urine, a variable temperature rising and falling above the normal line, and a concomitant exhaustion. There may, however, be no diarrhœa at all.

Types.—Simple, pneumonic, icteric.

Differential Diagnosis.—Distinguish from ordinary diarrhœa, enteric fever, and cholera nostras.

Mortality.—This is greatest during the first nine months of life. It is about 30 per cent. in children under one year. Half the fatal cases terminate within a week, and are chiefly confined to infants and feeble old people. It is higher in illegitimate children and bottle-fed infants.

Incidence.—Age.—It is essentially a disease of infants, but no age is exempt.

Sex.—Males are more liable at all ages.

Season.—It is always most prevalent in the summer, reaching its maximum in August, and being worse in dry seasons.

Temperature.—The summer rise of diarrhœal mortality follows the attainment of a temperature of 56° F. at a depth of 4 ft. in the earth.

Recurrence.—An attack confers no immunity.

Isolation and Quarantine are not required.

Method of Transmission.—*Aerial.*

Alimental, as from water, milk, and butter.

Direct corporeal, as from the discharges.

Indirect corporeal, possibly through the medium of flies.

Prevention of Origin and Spread.—The avoidance of organic pollution of the soil. The absolute avoidance of made soils as sites for dwellings. The avoidance of low-lying and ill-drained sites, and the crowding together of dwelling-houses. The exclusion of soil air from houses. Free ventilation. Sanitary larders. Disinfection of excretal evacuations. In short, deficient dissemination of fresh air, dirt, darkness, destitution, and dampness favour epidemic diarrhœa, and, if possible, have to be remedied or avoided.

Diphtheria.

Geographical Distribution.—A disease of cold and temperate climates, though known also in some tropical and sub-tropical countries. It was at one time most prevalent in country districts, but latterly has become more and more urban in its distribution. It may be endemic, epidemic, or sporadic.

Etiology.—Diphtheria is caused by the Klebs-Löffler bacillus, an organism which is present in the mucous membrane affected by the disease, and which there produces those toxic products that pass into the system. It also occurs in the secretions from those mucous membranes, but does not itself invade the general circulation, except prior to death in fatal cases. The organism has been recovered post-mortem from the lungs, spleen, liver, etc. It was not found in the urine in seventeen cases examined by one of us, but in three of these cases a streptococcus was present in the urine.

In the mucous membrane it is as a rule associated with strepto- and staphylococci, which may play a part in determining the nature of the disease. Pure diphtheria is due to the Klebs-Löffler bacillus, septic diphtheria to the action of the bacillus combined with strepto- and staphylococci.

The diphtheria bacillus is a slender rod, straight or slightly curved, non-motile, and with highly refractile protoplasm (Plate III. Fig. 6 (*a*)). It is, however, highly pleomorphic, there being long, short, and aberrant forms. It does not form spores. Microscopically, a group of the bacilli together present the so-called "Chinese character" appearance, in shape resembling a number of Chinese letters scattered about the field.

Cultural Characteristics.—The best media are blood serum and serum agar, the gelatine preparations not being suitable. There is no liquefaction produced, and the suitable temperature is that of the body. The bacillus, which is aerobic, will not grow at room temperature. The growth is in the form of small circular individual colonies, with opaque greyish or yellowish centres and less opaque margins (Fig. 8). This appearance has given rise to a comparison with the heads of daisies and the application of the term "marguerite" forms. In broth there is a general turbidity followed by a flocculent deposit and a clearing of the upper part of the medium.

Staining.—This is important from a diagnostic point of view, owing to the metachromatic qualities of the bacillus shown by Neisser's method. With the oil immersion lens the bacilli are seen to be of a light brown colour, and show bluish dots at intervals along the rods, usually placed terminally and at the centre (Plate III. Fig. 6 (*a*)). The best ordinary stains are carbol-thionin-blue and methylene-blue, while the colour is retained in Gram's method.

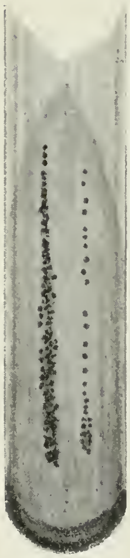


Fig. 8.—*B. diphtheriæ* on agar; twenty-four hours' growth.

An irregular staining of the protoplasm is very characteristic, the ends and the middle of the rod being most deeply coloured, though sometimes the stain is principally confined to one end (Plate III. Fig. 6 (*b*)).

The bacilli are much more resistant in dry membranes and cultures than under moist conditions. Bacilli resembling the Klebs-Löffler organism, and termed pseudo-diphtheria, have been described in the throats of healthy persons as well as in those the victims of diphtheria. Some of these may be attenuated or vegetating diphtheria bacilli. The diphtheria bacilli produce, both in the body and in culture, toxines of various chemical composition, some of which are capable of producing paralytic symptoms like those occasionally following attacks of diphtheria.

Description. — Diphtheria is a disease affecting human beings, cats, and probably cattle. Analogous diseases in other animals are due to organisms totally different from the Klebs-Löffler bacillus, but cows, according to Klein, can be inoculated with true diphtheria.

The *incubation period* is from two to seven days.

Symptoms.—The onset is fairly rapid, and associated with pain in the throat, difficulty in swallowing, feverishness, headache, nausea, a weakness of the legs, and general discomfort, causing loss of sleep. The glands of the neck are frequently enlarged. After a few hours, or several days in the case of faucial diphtheria, patches of a tough grey membrane appear on the back of the pharynx, the tonsils, or the soft palate, and spread till they coalesce. This membrane is due to a necrotic process, and is composed of dead epithelium, inspissated mucus, and food débris, and forms the home of the bacillus. The parts of the throat unaffected by membrane present a dark, angry, congested appearance. The membrane may invade either primarily or secondarily the nasal mucous membrane, or the larynx, or both, and the toxines manufactured therein pass into the general circulation, giving rise to the paralytic and other symptoms characteristic of the disease. The mucous membrane of the œsophagus, vagina, and the eyes, and the open surfaces of recent wounds, are also liable to diphtheritic inflammation.

Types.—Pure and septic, either of which may be nasal, faucial, laryngeal, or aberrant.

Differential Diagnosis.—Distinguish from follicular tonsillitis, scarlet fever, croup, and septicæmia. In taking a swab from the membrane, sterile but not antiseptic wool is to be employed. It should be fixed upon a metal holder, and is conveniently kept in a plugged and sterile test-tube, to which it is at once returned after the swab has been taken, the mouth and wool stopping of the tube being flamed to prevent contamination.

Mortality.—It is greatest in females, and at the fourth year of life. The average for all ages is from 15 per cent. to 20 per cent. A reduction may be expected in the more recent statistics, owing to improved therapeutic measures.

Incidence.—*Age.*—The disease is largely one of childhood, its main incidence falling on children of from 3 to 12 years.

Sex.—Females are probably more liable than males, at least this seems to be the case in school children.

Season.—Autumn and winter.

Race.—No race seems exempt.

Recurrence.—The protection conferred by one attack is of the slightest. Indeed, it is a moot point as to whether it does not predispose to a second invasion.

Isolation has to be continued for three weeks after the total disappearance of the local symptoms. It must be noted, however, that the diphtheria bacillus may persist for months in the throats and noses of those who have suffered from the disease, but, under normal conditions, it does not appear to be in a virulent state. Nevertheless, bacterial examination of the throat and nose secretions should be conducted during convalescence.

Quarantine.—Ten days.

Method of Transmission.—*Aerial, alimental, fomital, direct corporeal, indirect corporeal.*

Aerial.—Apart from inhalation directly from the patient, diphtheria may be spread considerable distances by wind convection. In this connection it should be noted that, while the emanations from drains will not *per se* cause the disease, they very markedly predispose to it from their tendency to reduce tissue vitality and produce sore throats.

Alimental.—There is no evidence of diphtheria being a water-borne disease, but it has been abundantly proved that milk and even cheese may convey the infection.

The milk may be infected from an antecedent human case, or possibly from the disease existing in cows.

Fomital.—Dried discharges on fomites kept in an ill-lighted and stagnant atmosphere retain their infectivity for long periods.

Direct corporeal, as from contact with the human patient or an infected animal.

Indirect corporeal.—The question of conveyance of the virus by flies and other insects must be considered; while it is known that the bacilli can exist for days and weeks in the throats of healthy people, who may thus convey the disease to others without themselves suffering in the slightest.

Prevention of Origin and Spread.—Notification. Isolation either in hospital or privately.

Quarantine.—This is of special importance in the case of children attending school. No child from an infected house should be allowed to continue its attendance.

School attendance.—As school attendance has been proved to disseminate diphtheria, the question of school closure has to be considered by the medical officer of health on the appearance of an outbreak. The aggregation of slight cases amongst a susceptible community may lead to an increase in the virulence of the disease.

Failing school closure, a daily medical examination of the throats and noses of all children attending school should be enforced.

General methods.—A bacteriological examination of suspected throats. Enlarged tonsils and adenoids should be removed in all children, to lessen the susceptibility to the disease and likewise its severity. Infected milk supplies must be prohibited ; it would be well if all milk were boiled during the prevalence of an epidemic. All insanitary conditions, especially damp, dirt, darkness, and defective drainage, must be remedied, as they predispose to the disease. Disinfection of buildings, fomites, discharges, and patients. The use of antiseptic throat gargles and applications in the case of contacts. Iodine is very fatal to the bacillus.

In a fatal case the body should be swathed in a sheet soaked in corrosive sublimate solution 1 in 500, the funeral should be private, all "waking" of the corpse forbidden, and cremation should be advised. Destruction of cats infected or liable to become so.

Antitoxine.—The treatment of all cases by the injection of an antitoxic serum of a definite strength, derived from the blood of an immunised animal, such as the horse (see pp. 267, 282).

Satisfactory results have been obtained in the immunisation of persons in infected households or institutions by the injection of No. 1 Behring serum. Its effects seem to confer protection for about three weeks, and it may therefore require repetition in twenty-five days.

The strength of the antitoxine used is expressed as so many units, a unit being ten times the amount of serum required to neutralise ten lethal doses of the toxine when injected into a guinea-pig of about 300 grms. weight.

According to Netter, preventive inoculation of contacts produces better results than bacteriological examination of their throats and isolation of those showing Löffler's bacillus. Since measles specially predisposes to diphtheria, Netter advises inoculation against diphtheria after an attack of measles.

Dropsy (Epidemic).

Syn., Acute Anæmic Dropsy.

Geographical Distribution.—It is a purely epidemic disease occurring in India and Mauritius. Three outbreaks have been noted in Calcutta.

Etiology.—Unknown.

Description.—It is a disease of families and communities, and seems to prevail after famine, though both weak and strong are liable to attack.

The *incubation period* is unknown.

Symptoms.—There is anasarca accompanied by fever. The dropsy affects the lower limbs at first, and spreads upwards, rarely affecting the face. The pleuræ and pericardium may contain effusion. A rash is frequent, beginning a week after the œdema, and lasting ten to twelve days. It is erythematous on the face, rubeolar on the trunk and limbs. The fever is mild and of a remittent type, and the disease persists for from three weeks to three months, and is accompanied and followed by marked anæmia and debility.

Differential Diagnosis.—Distinguish from beri-beri mainly by the absence of anæsthesia or paralysis.

Mortality.—The case mortality is 2 to 8 per cent.

Incidence.—*Age.*—Adults are chiefly affected.

Sex.—Amongst adults, males are more frequently the victims. In children the liability is equal in both sexes.

Season.—The cold season in India, where cold and dry weather favours outbreaks. Season exerts no influence in Mauritius.

Race.—Europeans are not affected.

Method of Transmission.—*Aerial and direct corporeal.*—Its spread is slow.

Prevention of Origin and Spread.—The ordinary sanitary precautions applicable to the exanthemata. There are no special indications.

Dysentery.

Geographical Distribution.—It is endemic in the tropics, epidemic in temperate latitudes. It was at one time endemic in Great Britain and Ireland.

Etiology.—It is highly probable that all cases of dysentery are not due to one specific organism. There is a possibility that the disease is dependent, in the first instance, on a catarrhal irritation of the intestinal mucous membrane excited by any one of a variety of circumstances operating in a suitable environment. For example, congestion of the mucous membrane of the large intestine of a debilitated or malarious person may be excited by a chill. This congestion is kept up and aggravated by bad food, impure water, undue exertion, or the swallowing of irritant dust particles. In certain countries subject to dust storms, the character of the sand particles swallowed is believed by some to have an influence on the production of the symptoms, owing to the presence of silicon. Under these abnormal conditions, the bacteria which always inhabit the large intestine, *e.g.* the *B. coli communis*, the *B. proteus vulgaris*, etc., may take on a virulence which they do not normally possess, and so contribute to an increase in the severity and extent of the catarrhal process. This, however, will not explain the absence of dysentery amongst some communities and its prevalence amongst others. At present the whole question is sub judice, especially as recent investigations in South Africa go to show that little faith can be placed in the theory that the much vaunted *Amœba dysenteriæ* plays a part in the etiology of South African dysentery at any rate, which many believe to be merely "diarrhœa writ large."

Elsewhere, however, the amœba may play a part in certain varieties of the tropical disease, though in all probability it is an accessory rather than an essential cause. The amœba is a rounded protoplasmic mass. When in motion two distinct layers can be distinguished, and pseudopodia are thrown out. The amœba is uninuclear (Plate IV. Fig. 1), and frequently contains vacuoles and blood corpuscles or bacteria. It has not been isolated in pure culture, but has been found in the stools, the bases of dysenteric ulcers, and the contents of post-dysenteric hepatic abscesses.

Shiga in Japan and Flexner in the Philippines have recently discovered in dysenteric cases a bacillus, identical in both instances, which is pathogenetic, and agglutinates with the blood serum of persons suffering from dysentery.

Description.—The disease affects both human beings and the lower animals, cats being specially prone to infection.

The *incubation period* varies from a few hours to several days, the time often depending on whether the infection is through the mouth or the rectum.

Symptoms.—The onset may be sudden, or the attack may be preceded by diarrhœa and colic. The characteristic symptoms are tenesmus, griping, abdominal tenderness, and the frequent passage with much straining of small muco-sanguineous stools. There may or may not be fever. As a sequel, hepatic abscess is not uncommon.

Types.—Catarrhal, ulcerative, gangrenous; also acute and chronic.

Differential Diagnosis.—Distinguish from epidemic diarrhœa, cholera, colitis, enteric fever, intussusception, rectal neoplasm, bilharzia hæmatobia.

Mortality.—It is less fatal to Europeans than to natives in India. The disease varies so much that no definite figures can be given.

Incidence.—*Age.*—All ages are affected in epidemic times.

Sex.—Indifferent.

Season.—In temperate climates it is most prevalent in the summer; in the tropics, during the cold season. Hot days followed by cold nights greatly favour the disease.

Race has no special influence.

Recurrence.—One attack probably increases liability to the disease, and certainly confers no immunity.

Isolation.—Till the stools become normal, except in the chronic form.

Quarantine.—Is not practised.

Method of Transmission.—*Aerial*, *alimental*, *fomital*, *direct corporeal*, and probably *indirect corporeal*, as from flies.

Aerial.—Dysentery may be produced by the ingestion of dust from dried dysenteric dejecta. The disease may be acquired per rectum from infected privies or latrines.

Alimental.—Dysentery is largely water-borne (see p. 191).

Fomital.—Infected instruments introduced into the bowel may set up the disease.

Prevention of Origin and Spread.—*Isolation.*—Dysenterics should not be treated in the same ward as patients suffering from enteric or other acute bowel affections. In the South African campaign the evil of so doing became evident on so many occasions, that it became the rule to treat dysentery cases in different wards from those occupied by enterics.

General Methods.—Water from any doubtful source should be avoided, or at least boiled. Disinfection of the evacuations, which should be buried or cremated. Irritating articles of food must be forbidden. Proper clothing and the wearing of cholera belts to obviate the risk of chill. Alcoholic stimulants are to be taken only in moderation. Guard against diarrhœa and constipation. In the case of institutions, such as asylums, overcrowding must be avoided. Pollution of the soil should be remedied where possible.

Febricula.

Syn., Simple Continued, Ephemeral, and Veldt Fever.

Under this heading are included a variety of febrile conditions occurring in all parts of the world, and due to divers ill-defined causes, such as the process of acclimatisation, exposure to the sun, starvation, chills, worry, insomnia, digestive disorders, the result of improper food, etc. There is probably no specific organism connected with the disease. The fever, which is sudden in onset, lasts from twenty-four hours to even ten days, the length of the attack being largely dependent on the persistence of the cause. It is characterised by malaise, headache, furred white tongue, nausea, occasional rigors, and a temperature varying greatly in degree, but which in bad subjects may be very high, and accompanied by delirium. It nearly always ends in speedy recovery. There is no exanthem, but sweat rashes are fairly frequent. It has to be distinguished from mild cases of enteric fever, typhus, and malaria. Some have gone so far as to say that all cases are one or other of these; but in the recent South African campaign, a goodly proportion of the cases returned as simple continued fever did not give the Widal reaction, and were certainly neither typhus nor malaria, while the soldiers suffering from it had been living under the very conditions which are said to be the exciting causes of febricula.

In this country the disease is most common amongst children. The number of cases is dependent rather on local or general conditions than on contact with the sick.

Prevention of Origin and Spread consists in obviating the various exciting causes already detailed.

Glandular Fever.

Geographical Distribution.—Germany, America, Britain.

Etiology.—Unknown.

Description.—The *incubation period* is seven days.

Symptoms.—The onset is sudden. There is pain in the neck and when swallowing, accompanied by a rise of temperature. On the second or third day of the fever there is swelling of the sterno-mastoid glands, usually beginning on the left side and becoming bilateral. There is abdominal pain and enlargement of the liver, spleen, and mesenteric glands. Obstinate constipation is frequently present. The fever lasts a fortnight or three weeks, and convalescence is prolonged for eight weeks.

Differential Diagnosis.—Distinguish from bubonic plague, mumps, and glandular affections. Also, in some instances, from enteric fever.

Mortality.—Trifling.

Incidence.—*Age.*—The disease attacks children and sometimes young adults.

Isolation should continue for three weeks from the onset.

Quarantine.—Seven days.

Method of Transmission.—*Aerial* and *direct corporeal.*

Prevention of Origin and Spread.—Isolation, quarantine, disinfection.

Gonorrhea.

Geographical Distribution.—Universal.

Etiology.—It is due to the gonococcus first described by Neisser. This is a coccus which frequently occurs in pairs, so shaped and applied to one another as to give the appearance of a couple of beans, each with its hilum opposed to that of the other, so that a clear space which does not stain is left between the two cocci. The gonococcus is present in the purulent discharge, chiefly within the leucocytes (Plate IV. Fig. 2).

Cultural Characteristics.—The most suitable medium is human blood serum. Serum agar is also good. The growth is best at body temperature, is rapid, and appears in the form of small, semi-transparent, isolated colonies with a wavy margin. Constant subculture is necessary, as the organism readily dies under artificial conditions. The gonococcus is aerobic.

Staining.—It stains readily with watery solutions of the anilin basic dyes, but does not retain the stain in Gram's method.

Description.—Gonorrhea is unknown in the lower animals, and cannot even be inoculated into them.

The *incubation period* is two to three days.

Symptoms.—They are those of a purulent urethritis lasting about six weeks, and sometimes passing into a chronic stage of gleet. In women the chief seats of the disease are the urethra and the cervix uteri. We are not here concerned with complications and sequelæ, but it must be noted that the conjunctiva may become infected.

Types.—Acute and chronic.

Differential Diagnosis.—Distinguish from simple urethritis, gout, rheumatism, and, in conjunctival affection, from other forms of conjunctivitis.

Recurrence.—One attack does not render immune, and any excess may induce a recurrence, the gonococcus long remaining latent in the urethra.

Incidence.—*Age.*—It is a disease of young adults, but no age is immune, and gonorrheal ophthalmia occurs in infants.

Sex.—Males are more liable than females, but the disease is more persistent in the female.

Isolation is not practised, but the period of infectivity is prolonged, the gonococcus in a virulent state having been found in the discharge two years after attack.

Quarantine.—If there are no symptoms within a week after exposure to infection, it may be taken that the disease has not been contracted.

Method of Transmission.—*Fomital* and *direct corporeal.*

Prevention of Origin and Spread.—As in the case of syphilis, the licensing and inspection of prostitutes has to be considered. Disinfection of the discharge and of the seat of the disease; also of infected fomites; burning of rags, protection of the conjunctivæ. Abstinence from sexual intercourse until any gleet has been completely cured. Sanitary precautions with regard to public conveniences. Persons infected should be warned against the use of public baths, and impressed with the danger of infecting others by means of urinals, water-closets, etc.

PLATE IV.

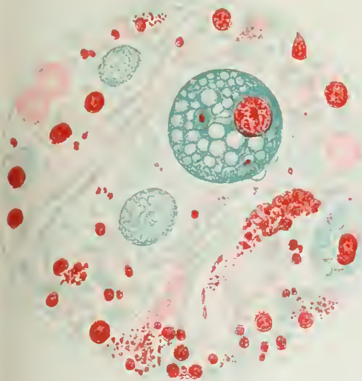


Fig 1.

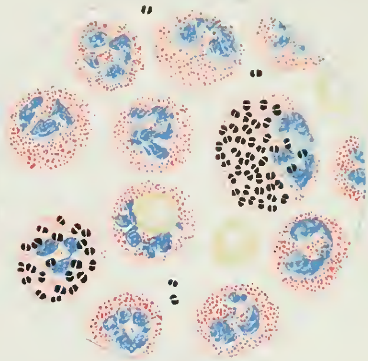


Fig 2

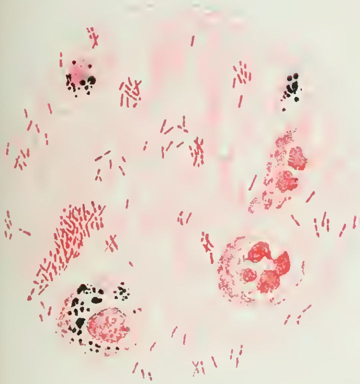


Fig 3.

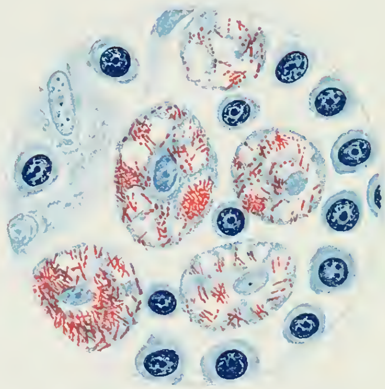


Fig 4

Fig 5

Fig 6.

FIGURE 1.—*Amoeba Dysenteriæ* in wall of liver abscess (× 1000 diam.). Benda stain.
,, 2.—*Gonorrhœal pus*, gonococci in leucocytes (× 1000 diam.). Formalin, eosin, and meth. blue.
,, 3.—*Bacillus Influenzæ* in sputum (× 1000 diam.). Fuchsin.
,, 4.—*B. Lepræ* in large phagocytic cells in sinuses of spleen (× 1000 diam.). Carbol fuchsin and meth. blue.
,, 5.—*Anopheles Maculipennis* (*a*) Larva.
,, ,, (*b*) Male.
,, ,, (*c*) Female.
,, 6.—*Culex Pipiens.*
(*a*) Male. (*b*) Female. (*c*) Larva (× 3 diam.).

Influenza.

Syn., La Grippe, Epidemic Catarrhal Fever.

Geographical Distribution.—It is an epidemic and pandemic disease independent of climate.

Etiology.—Influenza is due to a specific organism, Pfeiffer's bacillus, which is found in the sputum and nasal secretion, occasionally also in the blood. Its toxines probably play an important part in the production of the disease. Microscopically, it appears as a minute rod without a capsule, and occurs singly or in clumps, but not in chains. It is non-motile, and does not form spores (Plate IV. Fig. 3).

Cultural Characteristics.—The best medium is agar smeared with human or animal blood. The growth is rapid, and appears as minute circular dots almost completely transparent. As the bacillus dies readily, frequent subcultures are required. It is strictly aerobic.

Staining.—It stains best with weak carbol-fuchsin, but loses the stain in Gram's method.

Description.—It is doubtful if true influenza attacks the lower animals, though the disease "pink-eye" in horses was once thought to be identical with it. The disease occurs at intervals of several years, and spreads in epidemic form over large areas of the globe, sometimes becoming pandemic. Arising in Russia and the east, it tends to spread westwards, following more or less irregularly the lines of traffic, and having its heaviest incidence on crowded communities. Minor attacks occur in the years preceding and following epidemic outbreaks.

The *incubation period* is less than a week, and may be only a few hours.

The *Symptoms* are those of a common feverish cold, from which influenza differs in the intensity of the fever, the prostration induced, the severity and site of the attendant headache, the excessive backache, the tendency to serious complications and death, the prolonged convalescence with subnormal temperature and debility, the frequency of sequelæ and relapses.

A scarlatiniform rash may accompany the fever.

Types.—Gastric, respiratory, and nervous, according to the system on which the main incidence of the disease may fall.

Differential Diagnosis.—Distinguish from coryza, pneumonia, and the early stages of enteric, rheumatism, and the exanthemata.

Mortality.—It is greatest amongst the old and debilitated. The case mortality is low, ·1 to ·16 per cent. Owing to the enormous number of cases during an epidemic, the deaths in a year may amount to several thousands. Further, the low case mortality is not representative of the deaths from influenza, many being classified under pneumonia and heart failure.

Incidence.—*Age.*—All ages are liable, but very young children are least affected.

Sex.—The liability is equal.

There is no special relation to *season* or *race*.

Recurrence.—One attack rather predisposes to a second.

Isolation is not practised, but is advisable for at least a week.

Method of Transmission.—*Aerial*, *fomital*, and *direct corporeal*.

Aerial.—The virus can be conveyed considerable distances by the wind.

The patient's breath is probably highly infectious from the very early stages.

Prevention of Origin and Spread.—*Isolation*, though not of necessity in hospital. Old people should be specially protected, as the disease is extremely fatal to them. Disinfection of sputum and nasal discharges. As aggregation of susceptible persons in confined atmospheres, such as theatres, churches, etc., not only tends to spread the disease, but induces increased severity of the virus, such meetings should be discouraged during epidemics. If, in any locality, the incidence of the disease falls most heavily on children, the medical officer of health may have to consider the advisability of closing all schools. Fresh air, good food, regular hours, and correct habits tend to prevent influenza.

Kala-azar.

Syn., Black Fever.

Geographical Distribution.—Parts of India, especially Assam.

Etiology.—The disease has been ascribed to one of two causes—(*a*) A variety of the malarial parasite ; (*b*) the ankylostomum duodenale, a form of intestinal worm.

Description.—*Symptoms.*—The disease is slow and wasting, and there is great debility produced, with extreme anæmia, intercurrent fever, and darkening of the complexion.

Mortality.—It is high, and the disease is very fatal to village populations.

Method of Transmission.—*Aerial* and *direct corporeal.*—From place to place by human intercourse.

Leprosy.

Geographical Distribution.—At the present day leprosy occurs widely in tropical and subtropical countries, and its ravages have been very great of late years in the Sandwich Islands. In Europe it still persists in Norway, and there are a few lepers in the United States and Canada. In temperate regions the disease cannot nowadays hold its own.

Etiology.—It is due to the lepra bacillus, which microscopically is a slight, non-motile rod, straight or a little curved, and usually occurring singly, though two may be seen lying end to end. It is found in the cells and lymphatic spaces, but has never been cultivated artificially.

Staining.—Carbol-fuchsin is the best stain, and the bacillus retains the stain in Gram's method. It is usual to make a contrast stain, as in tubercle (Plate IV. Fig. 4).

Description.—The disease is not communicable to the lower animals, nor does it occur in them.

The *incubation period* is always long, a few weeks to several years.

Symptoms.—Leprosy is one of the granulomata affecting the skin and nerves, characterised by prodromal febrile attacks and occasional excessive sweating. Thereafter macular eruptions make their appearance, chiefly on the free extensor surfaces of limbs, tending to become pigmented and accompanied by anæsthesia. There is loss of hair at this stage. Secondly, there is the characteristic production of new growth affecting the skin (tuberculous), the nerves, and giving rise to white skin patches (anæsthetic), or both of these varieties (mixed). At later stages extensive and mutilating ulceration takes place, also pareses and trophic lesions. The average duration of the tuberculous type is eight to ten years; of the anæsthetic or nervous, eighteen years.

Types.—Tuberculous, anæsthetic; mixed.

Differential Diagnosis.—Distinguish from syphilis, lupus, other skin diseases, Raynaud's disease, and diseases of nerves.

Mortality.—The disease is generally fatal in the long run.

Incidence.—*Age.*—Leprosy is very rare under 5 years of age, and does not often start in persons over 40.

Sex.—The sexes are equally liable. It has no connection with *season.*

Race.—No nations are exempt.

Isolation should be continued as long as the disease persists.

Quarantine useless.

Method of Transmission.—*Fomital.*—In leprous countries washerwomen are frequently affected.

Direct corporeal.—Leprosy has never been known to invade a virgin country without the prior advent of a leper therein. The disease was once supposed to be due to fish food and defects in dietary, but most observers have abandoned this hypothesis. Leprosy is not hereditary.

Prevention of Origin and Spread.—*Isolation.*—A modified segregation is to be aimed at. All children born in leper settlements should be removed therefrom, and, if necessary, cared for at the public expense. It is impossible to completely isolate every case, but no leper should be allowed to attend fairs and public gatherings, or to carry on any occupation which will bring him into contact with the healthy, or which is concerned with the preparation of food or clothing. Leper mendicants should be strictly isolated. If a leper be isolated at home, he must have his own clothes, bed, food utensils, etc. Removal to a climate where leprosy is unknown is often very beneficial, especially in the case of Europeans. In all cases, strict cleanliness should be enforced, especially in the later ulcerative stages.

Disinfection of discharges, clothes, furniture, and dressings. In this connection it is to be noted that the bacilli have been demonstrated in the nasal secretions, saliva, urine, and milk of lepers.

In countries where leprosy is prevalent, calf lymph alone should be used for vaccination.

Malaria.

Syn., Paludism, Ague.

Geographical Distribution.—Malaria occurs in irregular endemic foci throughout the whole world, especially near the equator. In Europe the Roman Campagna forms a notable habitat of the disease. From early times the association of malaria with marshes has been recognised. The West Coast of Africa between the mouths of the Niger and the Congo may perhaps be described as *par excellence* the habitat of malaria.

Etiology.—Malaria is a disease due to a parasite belonging to the sporozoa, which is capable of becoming parasitic and of multiplying in man. It is an intracorpuscular hæmoparasite closely allied to the coccidia, which are minute, capsulated, protoplasmic bodies. The term "plasmodium," as applied to the parasite, is erroneous, though sanctioned by long habit. The poison circulates between man and the mosquito. As far as is known, it is not communicated by man to man, but by man to the mosquito, and by the mosquito to man. Maintenance of the parasite in successive generations of mosquito is secured by means hereafter described. The most suitable temperature for the parasite is 20° to 25° C. All varieties of mosquito are not capable of harbouring and conveying the parasite. Several species of the genus *Anopheles*, such as *A. claviger* or *maculipennis* (Plate IV. Fig. 5), *A. bifurcatus* (Italy), *A. superpictus* and *pictus*, *A. pseudopictus*, *A. rossii* (India), *A. funestus*, alone act as hosts as far as at present known. This genus is by no means confined to malarious districts, which fact will perhaps explain the occurrence of malaria in places where one would not have expected its presence, but into which it must have been imported by a man or animal harbouring the specific parasite. It is believed that the reduction of ague in England is dependent on the numerical reduction of the genus *Anopheles*, owing to improved drainage of land.

The species of *Culex* (Plate IV. Fig. 6) and other gnats do not transmit or accommodate the parasite.

The following are the distinctions between *Anopheles* and *Culex*:—In *Anopheles* the palpi in both sexes are equal to the proboscis; in *Culex* the palpi in the male are the same length as the proboscis, but in the female they are shorter.

The young of *Culex* in water hang head downwards at right angles to the surface, and have caudal breathing organs, while those of *Anopheles* float flat, and have no caudal breathing tube.

When resting on a wall, the body of *Culex* is parallel to the surface, that of *Anopheles* is at right angles. *Anopheles* requires certain algæ-haunted waters, which are not necessary to the life of *Culex*.

Certain of the species of *Anopheles* infest the neighbourhood of human habitations, usually haunting umbrageous retreats, and lay their eggs in clear, slowly running or stagnant waters, which are relatively cool in summer and warm in winter. Sulphurous, sea, and other saline waters are inimical to the larvæ. By day the insects lie perdu in damp sequestered spots, and swarm forth at night to feast on the blood of man. They do not travel far from their birthplaces, and do not fly at any considerable elevation, while strong winds discourage their predatory raids. The *Anopheles*, unlike the *Culex*, is a silent visitant, coming like a thief in the night, so that its presence may never be detected or its bites felt by its sleeping victim. The larvæ of *Anopheles* live in any water, clean or foul, clear or turbid, acid, alkaline, or ferruginous. They do not live in water containing salt, in strong sulphur waters, in putrid waters, in those with movement, or those devoid of aquatic plants. Rice fields constitute a favourite nidus.

Let us suppose that a variety of female *Anopheles* withdraws blood from a man who is suffering from malaria. Along with the blood there are sucked up certain young forms of the specific organism which is the cause of the disease. These young forms may be either free in the plasma or contained within the red blood corpuscles. They pass into the middle intestine of the mosquito, which, having gorged itself, looses its hold and flies away. Within the insect these young forms undergo certain changes to enable them to penetrate from the intestinal canal into the tissues of the mosquito. They are seen as oval pigmented cells (impregnated macrogametes), which grow, acquire a capsule, and project like warts (zygotes) on the outer surface of the mosquito's stomach into the body cavity of the insect (Fig. 9, *d* and *e*). Minute spheres (blastophores) are formed in the interior of the capsule, and on the surface of each of these, spindle-shaped germinal rods (sporozoites) develop, each spindle being attached by one extremity to its corresponding sphere. The pigment and spheres vanish, and only the capsule and sporozoites are left. After six days to three weeks, rupture takes place (Fig. 9, *f*). The time depends upon the temperature. The capsule contents pass into the body cavity and blood of the mosquito, and the sporozoites in this way reach the veneno-salivary gland of the insect.

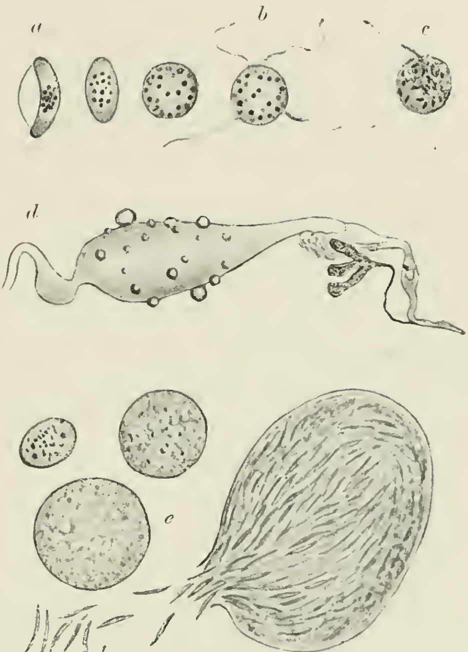


FIG. 9.—Evolution of malarial parasites in the mosquito. *a*, *b*, Stages of the gametocyte (from crescent to flagellated body). *c*, Macrogamete, showing entrance of flagellum. *d*, Stomach and salivary gland of mosquito, showing different stages of the zygotes passing through wall of stomach. *e*, Zygotes at different ages. *f*, Rupture of zygote capsule and escape of sporozoites.

The latter is now in a condition to infect another man, and if she bites, the so-called plasmodium (sporozoite) is introduced into the plasma of the blood stream. Now this plasmodium is not all of one kind. Several varieties or species exist, having life-cycles of different lengths, which determine the intervals between the febrile paroxysms characteristic of malarial fever. The next thing that happens is the entry of the plasmodium, now a minute, colourless sphere, into the red blood corpuscle. The mode of entry is unknown; but as soon as it is included in the corpuscle it exhibits amœboid movement, shooting out and retracting long pseudopodia, and growing at the expense of the hæmoglobin. It absorbs and breaks up the red colouring matter, so that, if viewed at this stage through the microscope, it appears as a pale, somewhat indefinite, protoplasmic disc occupying more or less space within the rim of the corpuscle. Scattered through this pale area are the black pigment grains of melanin derived from the disintegrated hæmoglobin.

The larger the plasmodium grows, the more sluggish is its movement, till finally all motion ceases, but not till the pigment particles have undergone more or less central aggregation and the pale protoplasm has arranged itself round the resulting masses in segments (spores), each somewhat similar to the form which characterised the plasmodium on its entrance into the human circulation from the mosquito, the whole arrangement being known as the "rosette" body (Plate V. Fig. 1). This is the sporocyte. The red blood corpuscle now breaks down, and the segments or spores fall apart, and with the pigment are set free in the liquor sanguinis. Phagocytosis now takes place, the pigment and many of the spores being absorbed by the leucocytes, and so passing out of this cycle. The remainder of the spores become attached to fresh red blood corpuscles, which they enter, and the cycle of events described above recurs.

The enormous destruction of red blood corpuscles resulting from the repetition of this process at once explains the anæmia which accompanies malarial fever. Having thus briefly considered the mosquito-man cycle of a plasmodium, we are in a position to describe the various forms in which this plasmodium occurs (Plate V. Fig. 2).

1. The parasites may be shaped like crescents (Plate V. Fig. 2). If the red blood corpuscle containing the segments does not completely dehisce, the crescent form of plasmodium, really plasmodium, pigment, and remains of the red blood corpuscle, is formed. There may be two crescents in the remains of one blood corpuscle, which perhaps was originally invaded by two plasmodia.

2. From the crescent comes the flagellated form. The crescent becomes first oval and then spherical, all signs of the red blood corpuscle vanish, there is agitation and rearrangement of the pigment particles, and the projection of flagella from the periphery of the new body thus formed.

To facilitate further reference, we term this the C variety. A similar flagellated body, which may be termed the O variety, can, however, be produced in another way. Sometimes a large intracorpuscular plasmodium may escape from the red blood corpuscle prior to the formation of the segments, and passing through the stage of agitation become flagellated. Both C and O varieties are called gametocytes (Fig. 9, *a* and *b*), which may be of two forms, hyaline and granular.

The flagella, which may be bulbous at the ends, are of the nature of spores. They may break away from their parent body, and if they do so, the latter becomes spherical and passive. Very frequently the whole flagellated body is absorbed by a leucocyte.

A flagellum set free from a hyaline gametocyte is known as a microgamete, and it can penetrate the granular form of gametocyte or macrogamete, thus apparently being the male form impregnating the female (Fig. 9, *e*). The macrogamete then changes shape, becoming the zygote already mentioned (p. 49).

Such changes have not been observed to occur in the human body, but they have been seen taking place to some extent under the microscope in the examination of human malarial blood, and to some extent in the stomach of the mosquito.

The student must remember that our knowledge is as yet far from complete on this subject, which is therefore still obscure and difficult, both of expression and comprehension.

For the perpetuation of the plasmodium, the human part of the cycle is not invariably required. The mosquito may transmit the organism to succeeding generations of its own kind. This is accomplished in the following manner:—The female *Anopheles* containing the plasmodium in its tissues lays its eggs in water, and as a rule dies beside them. The larvæ develop, and promptly devour the body of the mosquito, consequently ingesting the parasite, which may have taken on a resting spore form, as a zygote (black spores of Ross). Further, they feed on any kind of organic matter in the water, and even if they do not eat the mosquito, they may in this way absorb the plasmodium. The theory at present held is that the plasmodia then develop as the larvæ grow and become mature mosquitoes. These insects in their turn infect their larvæ, and so on ad infinitum.

Manson adduces the following proofs that the plasmodium is the cause of malaria :—

1. Its presence in every case of malaria which has not been treated with quinine.

2. Its absence as a cause in any other disease.

3. The coincidence of the symptoms with the life-cycle of the particular species of plasmodium present.

4. Melanæmia and visceral pigmentation pathognomonic of malaria being due to the melanin product of the plasmodium.

5. Quinine, which cures malarial fever, rapidly causes disappearance of most forms of the parasite from the blood, but not those forms unassociated with fever.

6. Experimental intravenous injection of malarial blood is followed by malarial fever and appearance of plasmodia in the subject of experiment.

7. The bite of mosquitoes whose salivary glands are known to contain sporozoites of the malaria parasite, is followed by the appearance of the malaria parasite in the blood of the person bitten, and by the clinical phenomena of malaria.

Examination and Staining.—The plasmodium cannot be cultivated artificially, so that it is necessary to stain the organism in the blood itself. A blood drop is carefully collected on a clean cover glass, which is then simply laid on a slide. This is best done before or at the time of rigor, and the plasmodia can be observed microscopically without the addition of stain, provided an oil immersion lens be employed. The staining methods in vogue are—(*a*) A contrast stain with eosine and methylene-blue ; (*b*) a contrast stain by the Ehrlich-Biondi method ; (*c*) a simple stain with borax and methylene-blue.

Description.—Malaria is a fever of a periodic type accompanied by anæmia, splenic enlargement, and the deposit of black pigment in the viscera and elsewhere. Similar symptoms are unknown amongst most of the lower animals, but forms of protozoa resembling the malarial plasmodium have been met with in the blood of birds and reptiles, and birds seem to suffer from attacks of ague.

The *incubation period* is from eight to ten days, but there may be a very prolonged and latent period.

Symptoms.—There may or may not be prodromata, and a period of apyrexia, either absolute or relative. follows the last of the three stages of the fever.

These are—(*a*) A cold stage with rigors and rising temperature ; (*b*) a hot stage with high fever ; (*c*) a stage of defervescence with sweating.

The continued attacks induce a cachexia mainly displayed in anæmia and splenic enlargement (ague cake). A particular and very fatal form of malaria is hæmoglobinuric or black-water fever, so called from the presence of blood-colouring matter in the urine.

Types.—All the clinical phenomena of the malarial attack depend on phases of the intracorporeal, though not necessarily the intracorpuscular, life of the parasite. In the prodromal stage, whether there be symptoms or not, the plasmodium is inside the red blood corpuscle, the pigment particles are collected into groups, and round them the spores are forming into segments.

The cold stage corresponds to the bursting and destruction of the corpuscle, the shedding of the segments and the pigment granules, and the breaking up of the segments into the separate sporiform bodies. The rigors of this stage are possibly due to the liberation of toxines accompanying this remarkable procedure.

The hot stage and the sweating stage occur when the sporiform bodies and pigment are free in the liquor sanguinis, when the former are endeavouring to enter fresh red blood corpuscles, and when the leucocytes are busy absorbing other of the sporiform bodies and the free pigment particles. It is presumed that the toxines are at this time undergoing elimination *viâ* the emunctories. The period of apyrexia is synonymous with the phase at which the young sporiform bodies, having effected an entrance into the red blood corpuscles, exist in them as the pale plasmodia which are preparing for the concentration of pigment and segment formation. All plasmodia are not quite the same, and take different periods of time to pass through these stages; hence the varying time between the recurrence of febrile attacks, which may be twenty-four hours, forty-eight hours, or seventy-two hours.

The clinical term quotidian has been conferred on a fever occurring every twenty-four hours; a tertian occurring every forty-eight hours; and a quartan every seventy-two hours. A quotidian form of fever may result from either (*a*) a parasite with a cyclical duration of twenty-four hours; or (*b*) what is called a dual tertian, which is a double tertian infection with the febrile stage of each occurring on alternate days; or (*c*) what is called a triple quartan, *i.e.* a treble quartan infection, whose febrile stages occur on each of three successive days. There is also a double quartan type.

There are benign and malignant forms of malaria. In the former, which may be tertian or quartan, the plasmodia do not form crescents, but are of the O nature (see p. 50).

In the latter, which may be quotidian or tertian, the plasmodia form crescents, being of the C nature (see p. 50).

What used to be known as remittent fevers are due to mixed infection.

Differential Diagnosis.—Distinguish from early tuberculosis, ulcerative endocarditis, pyelitis, septicæmia, and pyæmia; also from enteric fever and febricula.

Mortality.—It varies greatly according to the type and the treatment adopted. In Italy it is greatest between the ages of 5 and 30.

Incidence.—*Age.*—It is more common, more severe, and more dangerous in children than in adults.

Sex.—Both sexes are equally liable.

Season.—The season of incidence depends on the life-history of the *Anopheles*, and therefore may not be at the same period of the year in different climates. In Italy the new uninfected generations of the mosquito begin to bite in the second half of June and the first half of July. They take up the plasmodium which develops in them, so that they are ready to transmit the disease in July and August. The true malarial season is thus in the second half of the year. From January to June malaria is much less prevalent, attacks at this season being as a rule recurrent manifestations of the primary infection received in the previous summer. In warm latitudes malaria is perennial, but most prevalent in the warmer parts of the year. A certain temperature is required for the full development of the sporiform bodies in the mosquito, a hot and lengthy summer prolonging the usual summer epidemic. A severe winter may, by killing off the insects, favourably influence the following malarial season. In places with an atmospheric temperature below 60° F., malaria is never contracted for the first time.

Rainfall.—A moderate amount of water is essential for the life of the mosquito, while either great excess or marked deficiency of rainfall may produce conditions inimical to it. A favourable nidus is a soil in which the ground water is high, especially if it appear on the surface and there remain stagnant or run very slowly.

Air.—The larvæ require air for their existence in water, and obtain it by means of slender tubes passing from them to the surface.

Race.—The dark-skinned races, especially the African and West Indian negroes, enjoy a certain immunity. It is, however, on record that in the American Civil War adult negro males were more liable than white soldiers. Some persons are not susceptible to malaria even though repeatedly exposed to infection. Races inhabiting malarial districts transmit no hereditary immunity, but are less liable than newcomers to the disease.

Recurrence.—A previous attack produces more or less immunity from fresh infection. Children in an infected area may acquire a considerable amount of protection in after life as the result of former attacks.

Method of Transmission.—Aerial, alimental, indirect corporeal.

Aerial, as from the inhalation of wind-borne dust consequent upon the drying and powdering of mud at the bottom of evaporated pools which have contained the larvæ; also from dust generated from broken-up soil containing the dead bodies of mosquitoes which have harboured the parasite.

Alimental, as from drinking-water becoming infected with such virus-laden dust, and the drinking of water in which malarial mosquitoes have died.

Indirect corporeal, from man through one or two generations of mosquito back to man again. Malaria was once supposed to be due to a miasma, but the valuable researches and discoveries of Ross and Manson have demonstrated that the mosquito is a sine quâ non in the production of malaria. Experiments founded on their theory, and carried out in Italy, have proved beyond all doubt that men can live and enjoy perfect health in the midst of the most malarious country, if only proper precautions are taken to prevent being bitten by mosquitoes. Further, a mosquito has been allowed to extract blood from a malarial subject in Italy. This insect was then conveyed to Britain and permitted to bite a man who had never had malaria, and had never been out of his native country. This man promptly developed the disease. In such experimental cases the incubation period appears to be eight to twelve days. It is not impossible that in Italy malaria may have been disseminated by arm-to-arm vaccination.

The disease can certainly be transmitted from one person to another, by the injection, especially intravenous injection, of blood containing the parasite, and it has been found that the type of malaria induced is similar to that which prevailed in the person whose blood was employed for the purpose.

Prevention of Origin and Spread.—To begin with the cause.

1. *Destroy the larvæ.*—This is best accomplished at the time when they

are in least numbers in the water, for example, spring and winter in Italy. It may be done by—

(*a*) The drainage of pools, swamps, and other breeding places. This can be directly effected by the planting of eucalyptus trees, which absorb very large quantities of moisture. Celli points out, however, that eucalyptus and pine trees should not be near houses, as they harbour the mosquitoes.

(*b*) The abandonment of rain barrels and the screening of water tanks.

(*c*) The use of petroleum, which, poured in the form of a film upon the surface of infected water, mechanically prevents access of air to the larvæ, and so brings about their death. The petroleum must form a stratum, covering the whole surface in a proportion exceeding ·2 c.c. per 100 c.c. of the water. It has the disadvantage of evaporating rapidly, and may require repetition. An ounce of kerosene should be applied once a month to every 15 sq. ft. of surface of the pool. There is no objection to coating the surface of water in cisterns, etc. with kerosene, if drinking-water is drawn from the bottom of the tank. Dr. Doty reports that the best results are obtained by introducing petroleum under the surface of water and stirring. He recommends Lima oil, a crude petroleum, in the proportion of about 20 drops to the gallon of water.

(*d*) The disinfection of the water by certain anilin dyes (larvicide of the house of Weiler-Ter-Mur of Uerdigen).

(*e*) The disinfection of the water by vegetable germicides, especially the unexpanded flowers of Dalmatian chrysanthemums.

(*f*) The stocking of infected pools with fish.

2. *Destroy the mosquito*—

(*a*) During hibernation, by the clearing away of rank and rotting vegetation, and by the thorough cleansing and disinfection of infected houses.

(*b*) During active life, by the fumes of zanzolin, a powder composed of the unexpanded flowers of the Dalmatian chrysanthemums, valerian root, and larvicide.

(*c*) During active life, by putting into force the Donnybrook principle, "When you see a head, hit it!" A more elegant and very efficacious mode of killing a mosquito found on a ceiling is by placing under it a shallow tin vessel nailed to the end of a stick and moistened on the inside with kerosene.

3. *Prevent the mosquito biting by*—

(*a*) Living from sunset to sunrise in mosquito-proof houses, or during those hours inhabiting a region devoid of mosquitoes. Avoiding the use of lighted rooms with unprotected windows.

(*b*) Mechanical means employed when out at night, such as masks and gloves, for the parts unprotected by clothing. Applications known as culicifuge soaps, containing turpentine, etc. may be spread over the face, neck, wrists, and hands when in the open air between sunset and sunrise. According to Celli, however, they are of little or no value.

4. *Isolation.*—A person suffering from malaria should be removed to an isolatorium in an elevated healthy district, not only for the benefit of other people, to whom he constitutes a danger by his liability to infect mosquitoes, but also for his own sake, to prevent him becoming the subject of mixed infection. Isolation ought to be continued till all signs of the plasmodium have vanished from the blood, but this is of course impracticable, and attention should be specially directed to only the more virulent forms.

5. *Disinfection of the blood* by the gratuitous administration of quinine, preferably given in effervescing mixture as recommended by Burney Yeo.

6. *The production of artificial immunity.*—This is at present the subject of further experiment. It has been found that a daily dose of half a grain euchinin confers protection. Methylene-blue is also a substance capable of producing immunity.

7. *General methods.*

(*a*) Proper clothing, housing, and feeding of the inhabitants of malarious districts. Special attention must be paid to house construction, and in Italy much has been done to render railway stations habitable without danger. Dark places in a house should be avoided, the walls should be white in colour, and any hole in the flooring should be carefully closed. To render a building mosquito proof, the walls of the verandah, if such exist, should be of fine net-work, and this should also be fitted to doors and windows. Wherever there is any strain to be withstood, it ought to be of metal, such as iron plated with zinc or tin, and the little square meshes should be 1 to 1·5 mm. on all sides.

Chimneys should be similarly protected, and beds must be guarded by mosquito curtains.

(*b*) The avoidance of chill, over-fatigue, and excess of any kind which may predispose to attack.

(*c*) Hydraulic sanitation, having for its object the lowering of the ground water, the prevention of stagnant aqueous accumulations, and the increasing of the velocity of sluggish streams.

The substitution of concrete channels for muddy ditches is advisable. It has been noted that the larvæ can exist even in rapid currents, provided they can obtain shelter in the still water formed by the leaves of trees dipping into the stream. Such leaves must therefore be cleared away.

Periodical cleansing of canals, combined, where possible, with periodical flushing by means of sea-water, are good preventive measures. For rice fields the only treatment is the use of the larvicide, manufactured by the firm of Weiler-Ter-Mur of Uerdigen.

(*d*) Agricultural improvements, ploughing, tree planting, and dry cultivation.

(*e*) The superimposing of fresh soil upon the mud of drained malarious pools and swamps.

(*f*) The utilisation of sea water as a means of purifying neighbouring fresh waters.

(*g*) Ground should not be broken up during the fever season, and no one should sleep near recent earth excavations.

Malta Fever.

Syn., Mediterranean Fever, Undulant Fever.

Geographical Distribution.—As one of its synonyms implies, it is largely confined to the Mediterranean littoral, though a similar fever has been recorded in India and China. It was first described in Malta; is endemic there, and may be epidemic.

Etiology.—It is due to the *Micrococcus melitensis* of Bruce, which is found only in the splenic blood. Microscopically, it appears as a very minute coccus, ovoid or circular in shape, with marked Brownian movement, at times to be seen in chains of two or more.

Cultural Characteristics.—The media must be slightly less alkaline than the human blood. The favourite temperature is 37° C. An agar growth takes place after five days, and appears as tiny, transparent, colourless dots, which become amber coloured and opaque. A general turbidity, followed by a deposit, is produced in broth. There is no pellicle. Gelatine is not liquefied.

Staining.—The organism readily takes up the basic anilin dyes, but alcohol easily removes the stain.

Description.—Monkeys can be inoculated with the disease, and the specific organism recovered from them will reproduce the fever in other monkeys within twenty-four hours.

The *incubation period* varies from three to fifteen days.

Symptoms.—It is a febrile disease of long and indefinite duration, the average stay in hospital being seventy to ninety days, characterised by an irregular course and undulatory pyrexial relapses, with constipation, profuse perspirations, splenic enlargement, anæmia, neuralgia, rheumatoid affections, and in man testicular pain. The fever lasts three weeks, with remissions.

Types.—Undulatory, intermittent, malignant.

Differential Diagnosis.—Distinguish from enteric fever, malaria, and relapsing fever.

Mortality.—The case mortality is low, being only ·2 per cent.

Incidence.—*Age.*—Persons at all ages suffer up to 50, the greater number being attacked between the ages of 6 and 30. The disease is rare above 50.

Sex.—Both sexes are liable, but men are more often attacked.

Season.—It is most common in hot weather. The incidence is low when the rainfall is heavy, and vice versâ.

Recurrence.—One attack confers immunity for some time, if not for the whole of life.

Isolation and *Quarantine* are unnecessary.

Method of Transmission.—Probably *aerial*, and connected with sewage emanations.

Alimental.—Like the enteric bacillus, the virus may possibly gain access to food and water.

Prevention of Origin and Spread.—It is not directly communicable from man to man. Avoidance of predisposing causes, such as chill and exposure to the sun, and general sanitary precautions are therefore the only means of combating it.

Milk-sickness.

This is a peculiar and rare disease in man, associated with the complaint known as "trembles" in cattle, and derived from the ingestion of the meat or the milk of diseased animals. It occurs amongst pioneer communities in America, but as it is rapidly dying out, and is of little sanitary interest, it need not be considered further.

PLATE V.

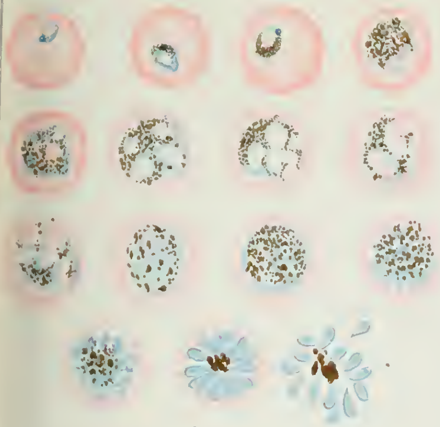


Fig 1

Fig 2

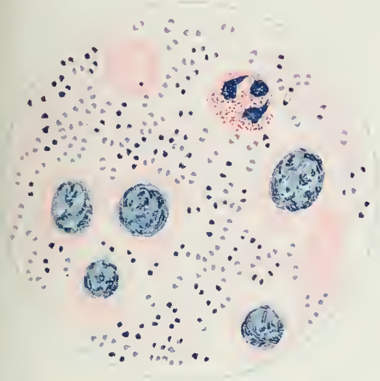


Fig 3

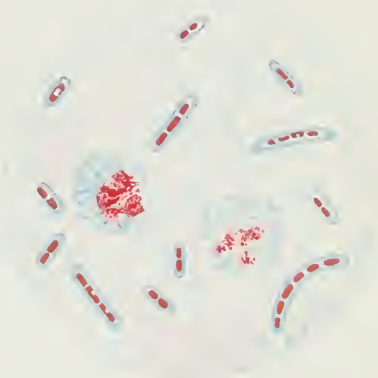


Fig 4

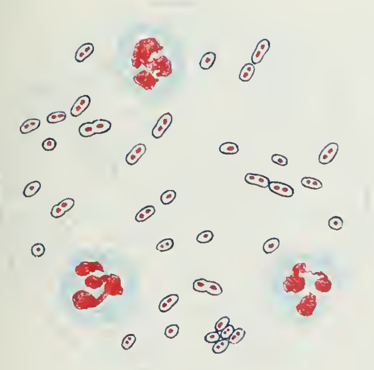


Fig 5

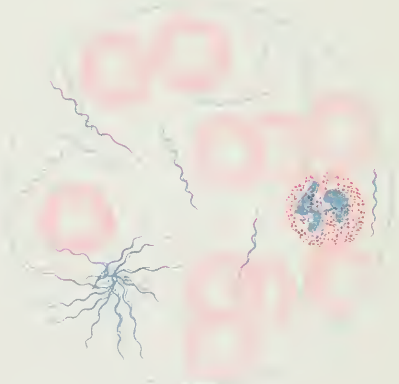


Fig 6

FIGURE 1.—*Malarial Parasites* (simple tertian) cycle of asexual forms (× 1000 diam.). Eos. and meth. blue.
,, 2.—*Malarial Parasites* (malignant), small ringed form (× 1000 diam.). Meth. blue and saffrin. *Crescentic* form (Gametes), and pigmented mononuclear leucocyte (× 1000 diam.). Eos. and meth. blue.
,, 3.—*B. Pestis*, scraping from bubo (× 1000 diam.). Eos. and meth. blue.
,, 4.—*Friedlander's pneumobacillus* in sputum, showing capsules (× 1000 diam.). Muir's method.
,, 5.—*Fraenkel's Pneumococcus* in pleural effusion, showing capsules (× 1000 diam.). Muir's method.
,, 6.—*Spirilla of Relapsing Fever, Blood Film* (× 1000 diam.). Formalin, eos., and meth. blue.

Mumps.

Syn., EPIDEMIC PAROTITIS, CYNANCHE PAROTIDEA.

GEOGRAPHICAL DISTRIBUTION.—An endemic, and at times epidemic, disease, urban in its distribution, and common in temperate climates.

ETIOLOGY.—Unknown, though Charrin and Capitan have described a non-motile, non-liquefying, spore-bearing bacillus, which they regard as the cause. Bordas confirms their observations, and regards infection as taking place through Stenon's duct. More recently a streptococcus has been described by Bein.

The *incubation period* varies from fourteen to twenty-five days.

SYMPTOMS.—There are usually some premonitory symptoms, such as fever and nausea, followed by pain in and swelling of one of the parotid glands, the other eventually becoming also affected in most cases. The submaxillary glands participate in the swelling, and metastases of the genital organs are frequent complications, especially in adults. Orchitis, following parotitis, commences on the eighth day, but rarely occurs if the patient is kept in bed till after that time.

MORTALITY.—Trifling, and confined to infants.

INCIDENCE.—*Age.*—Children between 5 and 15 years are specially attacked.

Sex.—Males are slightly more liable than females.

Season.—Spring and autumn are the periods of greatest incidence.

RECURRENCE.—One attack usually confers lifelong immunity.

ISOLATION should continue for three weeks.

QUARANTINE.—Three and a half weeks.

METHOD OF TRANSMISSION.—*Aerial and direct corporeal.*

PREVENTION OF ORIGIN AND SPREAD.—Notification, isolation, quarantine, antiseptic gargles, general sanitary precautions.

Oriental Sore.

Syn., DELHI BOIL.

GEOGRAPHICAL DISTRIBUTION.—It is endemic in Egypt, Syria, India, and other countries. It has largely an urban distribution.

ETIOLOGY.—Unknown.

DESCRIPTION.—The disease is known amongst the lower animals, especially dogs.

The *incubation period* varies from a few days to several weeks.

SYMPTOMS.—The disease is one of the granulomata, and is characterised by the presence of itching papules on the skin, which become boils and then ulcers, are slow in healing, and leave depressed scars. The duration of the disease may be one year or even more.

DIFFERENTIAL DIAGNOSIS. — Distinguish from syphilis, rodent ulcer, epithelioma, yaws, and malignant pustule.

MORTALITY.—Trifling.

INCIDENCE.—No special relation to *age* and *sex*. As regards *season*, it is most prevalent during the passage of the hot season into the cold.

RECURRENCE.—Second attacks are rare.

Method of Transmission.—Direct corporeal.—The discharge from the sores is capable of producing the disease in monkeys and man.

Indirect corporeal.—This is doubtful, but insects may play a part in the transmission.

Prevention of Origin and Spread.—Cleanliness and general sanitary precautions have done much to diminish the prevalence of the disease.

Plague.

Syn., Pestis, Bubonic Plague.

Geographical Distribution.—Plague may exist as a pandemic, an epidemic, and a sporadic disease. It is endemic in China and the Euphrates valley; and epidemic in Egypt, India, Africa, Europe, and Australia. From early times epidemics of plague have been recorded, of which the most notable in this country was the Black Death of 1664–65. In the Middle Ages plague at times invaded Europe, spreading from east to west, and when it did so, its ravages were terrible, and well-nigh every town and city echoed to the mournful cry, "Bring forth your dead!" For a long period Europe was exempt, but of late years, no doubt owing to rapid and frequent communication with the East, plague has again appeared as a European visitor. Further, it has recently obtained a footing in Australia and South Africa. When epidemic, it as a rule starts in seaport towns, such as, to take recent examples, London, Glasgow, Liverpool, Lisbon, Oporto, Sydney, and Cape Town. Its rate of extension between countries is, however, slow.

Fig. 10.—Culture of *B. pestis* in butter broth; typical stalactite growth.

Etiology.—Plague is due to a specific bacillus, that of Kitasato and Yersin, which is found in the discharge from the buboes and in the blood, especially prior to death. In the juice from inflamed lymphatic glands, the plague bacilli are present in almost continuous masses, singly, in dumb-bells, or in small groups. They also occur in the spleen, have been demonstrated in the intestinal contents, in the pneumonic type are present in large quantities in the sputum, and plague bacilluria frequently exists. Microscopically, as usually seen, it appears as a small oval organism, with rounded ends, non-motile, and without spores or flagella (Plate V. Fig. 3). Kitasato affirms that in recent smearings from bubonic pulp or blood, a capsule can be seen, and the bacillus is markedly motile. In the buboes staphylo- and streptococci often accompany it.

Cultural Characteristics.—The bacillus grows best at body temperature and aerobically, but it can easily withstand anaerobic conditions. In broth with a few drops of sterile clarified butter on the top, there is a whitish deposit. In ghee broth there is a whitish pellicle, with dependent stalactitic prolongations (Fig. 10), which on shaking fall slowly to the bottom, like a shower of snow, or rapidly like falling icicles. On agar and blood serum, small round discs, with shining surfaces, occur. On slope agar, a grey translucent film develops, which is slimy and viscid in character. Jelly is not liquefied. As the organism grows in age, it loses its virulence and the typical microscopic appearance described above, taking on numerous involution forms, including chains.

The bacilli in culture tend to adhere together, but an emulsion can be prepared in saline solution. Agglutination can be obtained with a serum derived from guinea-pigs which have been injected with sterile salt emulsions or mild living cultures. For test by inoculation guinea-pigs answer best, and then white rats.

Heat and sunlight are very inimical to the bacillus, which is killed by thorough drying and by a heat of between 62° and 65° C. in ten minutes. It is very resistant in the dark at moderate temperature.

Staining.—The bacillus absorbs the ordinary anilin stains, thionin-blue answering very well, and is characterised by bipolar staining, the ends of the protoplasm staining more deeply than the centre, thus presenting a characteristic appearance (Plate V. Fig. 3). Cover-glass preparations from slope agar, however, rarely exhibit this peculiarity.

Aoyama affirms that the bacilli found in the glands are decolorised by Gram's method, while those present in the blood retain the stain.

Description.—Plague is known to occur naturally in cats, rats, mice, and insects, and is inoculable into guinea-pigs and rabbits.

The *incubation period* varies from three hours to fifteen days, but is usually from two to eight days.

Symptoms.—The onset is usually sudden, with fever and headache, followed by the development of buboes in the groins, armpits, and neck. Primary buboes almost invariably develop in those glands which are connected with the cutaneous lymphatics. Petechiæ, hæmorrhages, and gangrene may be present, which of old gave rise to the name of "the Black Death." The eyes become injected, and the gait is staggering, resembling that of a drunk man. Delirium, coma, and other nervous phenomena may usher in death, which usually occurs on the third or fifth day, and may be the direct result of asthenia or syncope. In non-fatal cases the disease runs its course within a month, lysis commencing in fourteen days. Buboes are rarely absent in the bubonic type, and then only in cases rapidly fatal.

Types.—According to severity, *Pestis fulminans* or *siderans*, *P. major*, *P. minor*, and *P. ambulans*. According to symptoms, bubonic, pneumonic, hæmorrhagic, nervous, and septicæmic.

Differential Diagnosis.—Distinguish from mumps, pneumonia, typhus fever, and malignant malaria.

Mortality.—The case mortality is more severe at the beginning and height of an epidemic, varying from 60 to 95 per cent. On an average it is 50 per cent. It varies much in different epidemics, and is less in Europeans than in Asiatics.

Incidence.—*Age* has very little influence on its incidence.

Sex.—In the tropics women are more liable owing to their indoor life.

Season.—It is checked by cold, and also by great heat accompanied by drought.

Race.—Plague is more common amongst the coloured races of mankind.

Recurrence.—An attack confers brief immunity, but seems to favourably modify subsequent invasion.

Isolation has to be continued for from six to eight weeks.

Quarantine, eight to twelve days.

Method of Transmission.—*Aerial*, *alimental*, *fomital*, *telluric*, *direct* and *indirect corporeal.*

Bubonic plague is very slightly communicable until the buboes burst or are opened, but this is not true of primary pneumonic plague.

Aerial.—The recent report of the Indian Plague Commission points out that the organism may gain access to the system through the mucous membrane of the nose, mouth, and pharynx, or by the conjunctival surface.

Alimental, as from food or drink infected through the agency of dust, insects, or rats. This channel of infection is in all probability very rare.

Telluric.—The bacillus is found in the soil. Oriental houses in many instances have floors of dried mud or sun-baked earth, and consequently infection may take place through the abraded skin, especially that of the feet. This is specially true of endemic plague, which is said "not to go upstairs."

Direct corporeal, as from rats and mice suffering from the disease.

Indirect corporeal.—The evidence available from India goes to discredit the suggestion that plague can be conveyed from the bite of suctorial insects.

Prevention of Origin and Spread.—Notification. The powers conferred by the Infectious Diseases Notification Act should be exercised on the advent of an outbreak. Isolation in special hospitals. Quarantine of contacts. Disinfection of buildings, fomites, discharges, excreta, contacts, patients, and corpses. Where there are crevices and holes in a dilapidated building, it may be necessary to remove both plaster and flooring to accomplish the purpose thoroughly. Places and fomites of little or no value should be given to the flames. All fomites ought to be sprayed with formalin before removal for steam disinfection. Cremation of dead bodies is to be recommended.

Placards requesting information regarding rat mortality should be posted, and a reward given for dead rats, as destruction of rats and mice is important. Their bodies should be burned without undue handling. It is to be noted that rats often die in large numbers before an epidemic. Remedying of defective drains, and inspection of granaries. Buildings liable to be infected by rats should have their basements concreted.

Compulsory inspection of all dead bodies prior to burial or cremation in order to discover infected houses and localities.

House to house inspection for the purpose of unearthing cases of *P. ambulans* which fill up the apparent intervals between epidemics.

Inquiries are to be made from dispensaries, hospitals, etc., for information regarding the prevalence of pulmonary and glandular affections, which might be unrecognised plague.

Temporary removal of the whole community from the stricken area may be necessary for the thorough eradication of the disease.

Care as to persons with wounds and scratches coming into contact with plague patients, and avoidance of catarrhal conditions.

Protection of the feet by boots, the legs by putties, and the hands by gloves, in the case of those engaged on plague duty.

The use of disinfectant mouth washes and proper precautions as to food and drink. General methods, such as free ventilation, the use of soap and water, etc.

Medical inspection of crews and passengers in ships leaving plague-stricken ports or the ports of plague-infected countries.

In the case of ships from "plague" ports, the special orders of the Local Government Board applicable to the disease are to be enforced (p. 537). In addition, all rats and mice on the ship must be destroyed. One of the methods employed is, after closing all outlets, to pump sulphur dioxide (SO_2) into the hold, etc., to a proportion of not less than 8 per cent. of the atmospheric air. As these rodents are in the habit of leaving and entering ships viâ chains, hawsers, and cables, it is necessary to have guards upon these, and to heave up gangways at night. The bilge-water should be limed till it is strongly alkaline.

The inoculation with a preventive and curative serum derived from the blood of horses which have been inoculated repeatedly with the virus of plague (Yersin), or a preventive serum obtained from dead cultures of the bacillus (Haffkine). Apart from any sanitary or therapeutic value, this has an excellent moral effect. The Indian Plague Commission have concluded that preventive inoculation—(1) diminishes the incidence of plague attacks on the inoculated population, but does not absolutely protect; (2) diminishes the death-rate among the inoculated, the rate of attack, and the case mortality; (3) does not protect for the first few days after it has been performed; (4) confers a protection which lasts for several weeks and possibly months; (5) is harmless if properly performed; (6) will not exhibit its full value till an accurate method of standardisation has been devised.

Pneumonia Epidemica.

Syn., Pneumonic Fever.

Geographical Distribution.—It has been known to occur in various parts of Europe, in the West Indies, North, Central, and South America, and India. The classical outbreak in England is that which occurred in Middlesborough in 1888.

Etiology.—In different epidemics different organisms have been found, and it is possible that there is no one organism etiologically responsible for all cases of epidemic pneumonia. The organism most constantly present in pneumonia is Fraenkel's pneumococcus (Plate V. Fig. 5). In a smaller proportion of cases, Friedländer's pneumo-bacillus (Plate V. Fig. 4) occurs, while in the Middlesborough epidemic, Klein discovered a bacillus closely resembling the *B. coli communis*. The same organism was present in the Scotter epidemic.

Fraenkel's pneumococcus occurs in the lung, sputum, and pleural effusions. It has also been found in cases of peritonitis, endocarditis, meningitis, and median otitis, and has been described in the healthy saliva. Microscopically, it appears as a small oval coccus generally arranged in pairs (*Diplococcus lanceolatus*), and sometimes in chains. The free ends of the coccus are tapering, and a capsule is frequently present. It is non-motile.

Cultural Characteristics.—It is preferably an aerobe, and will not grow on acid media. It thrives on the ordinary media, especially blood serum, forming a transparent, delicate pellicle with isolated marginal colonies, whitish grey in colour and circular in shape. Gelatine is not liquefied, and there is no growth on potato. In no artificially cultivated specimen can a capsule be demonstrated. Frequent subculture is required if the coccus is to maintain its vitality. In any case, virulence is rapidly lost.

Staining.—It stains readily with the basic anilin dyes, and retains the stain in Gram's method.

This was the organism found in an outbreak in a Bavarian prison.

Friedländer's pneumo-bacillus occurs in the sputum and tissues, and may be present in the healthy mouth secretions. Microscopically, it is seen to be a short, non-motile rod with rounded ends and possessed of a capsule.

Cultural Characteristics.—There is a typical appearance in gelatine stab, the growth resembling a long nail with a white rounded head driven into the medium, the knob remaining free (Fig. 11). There is no liquefaction, but sometimes slight gas formation takes place. On potato a moist white layer develops.

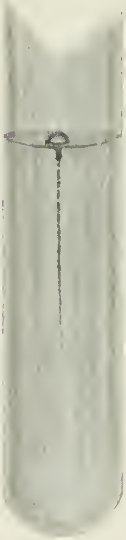


Fig. 11.—Friedländer's pneumo-bacillus; gelatine culture; one week's growth.

Staining.—It readily takes up the basic anilin dyes, but loses the stain in Gram's method.

Middlesborough Bacillus of Klein.—It was found in the juice from the inflamed lung, and appeared microscopically as a short bacillus with oval ends, occurring singly and in dumb-bell form. Klein described a short and a longer form, while a certain proportion of the bacilli were actually motile. It is distinct from the pneumococcus and pneumo-bacillus.

Staining.—It stains well with gentian violet.

Cultural Characteristics.—It is aerobic, does not liquefy gelatine, and both on jelly and agar streak forms a greyish white growth with serrated margins.

Description.—Epidemic pneumonia in animals takes the form of a pleuro-pneumonia, and is common in cattle.

The *incubation period* varies from a few hours to a week, but is usually eighteen to thirty-six hours.

Symptoms.—The onset is usually sudden, with rigors, cough, and headache. The temperature rises, there is often thoracic pain, and rusty-coloured sputum is expectorated. Delirium is common. It is often difficult to recognise the disease at the early stages, the physical signs being masked. Indeed, it is very often a "pneumonic fever," and there may be no marked pulmonary symptoms at all. The disease is frequently fatal about the fifth day, but in non-fatal cases the crisis may be expected about the sixth or eighth day, except in so-called typhoidal cases. Epidemic pneumonia is of the croupous type in nearly all instances. It is frequently apical, like alcoholic pneumonia, and nervous symptoms are often marked. Complications are both common and severe.

Types.—Typical, typhoidal.

Differential Diagnosis.—Distinguish from enteric fever, ordinary and alcoholic pneumonia, pyæmia, typhus fever, and meningitis.

Mortality.—It is greatest in females, and at the extremes of life. The case mortality varies with the epidemic, and small epidemics are often the most deadly. It was 21 per cent. in the Middlesborough epidemic, and usually ranges between 5 and 40 per cent.

Incidence.—*Age.*—In the Middlesborough epidemic the main incidence fell on persons at the working ages, *i.e.* above 15 and under 65 years.

Sex.—Males are more frequently attacked than females, from the nature of their occupations.

Season.—Winter and spring. It is largely dependent on the intensity of the changes of temperature. Heavy rain tends to "drown out" an epidemic.

Race.—Negroes are peculiarly liable to epidemic pneumonia.

Recurrence.—One attack predisposes to a second.

Isolation is important, though it is apt to be neglected.

Quarantine.—Seven days.

Method of Transmission.—*Aerial*, as from the breath.

Alimental.—Well seen in the Middlesborough epidemic, where the cause of the epidemic was found to be the eating of bacon infected with the *B. pneumoniæ* of Klein. Mice fed on the bacon died from pneumonia, and the bacillus was recovered from the victims in a virulent form. No definite proof is forthcoming as to how the bacon came to contain the organism.

Fomital, as from dried sputum on clothes, etc.

Direct corporeal.—*Indirect corporeal.*—Instances of the conveyance of the disease by a third person have been reported.

Prevention of Origin and Spread.—Isolation: quarantine; disinfection of buildings, fomites, and sputa. General methods, such as ventilation, prevention of overcrowding, sanitary dwellings, properly placed and constructed meat safes, larders, and meat storage chambers, good food, etc. The importance of disinfecting buildings is shown by the fact that repeated epidemics are liable to occur in certain habitations, such as barracks, jails, training ships, etc.

The use of antipneumo-toxine, derived from the sera of animals which have been immunised by the intravenous or subcutaneous injection of pneumotoxine, a product of the cultivated pneumococcus in the form of a glycerine extract of the culture or the filtered culture itself. It is of doubtful benefit, but the outlook is hopeful, progress being directed along proper lines.

Puerperal Fever.

Geographical Distribution.—World-wide.

Etiology.—All cases are not due to the same organism. The pyogenic cocci are usually credited with being the cause, especially the *Streptococcus pyogenes*. Staphylococci, gonococci, and *B. coli communis* have been found in the infected tissues and the discharges from them.

Description.—The *incubation period* varies from twenty-four hours to two or three days.

Symptoms.—There is an initial rigor with a rapid pulse before the fever commences; then a continuous high temperature, or a temperature with marked remissions and exacerbations.

Types.—Scarlatiniform, erysipelatous.

Differential Diagnosis.—Distinguish from milk fever.

Mortality.—It is higher in private than in hospital practice. From two to three deaths occur for every 1000 children born.

Method of Transmission.—*Aerial*, as from sewage emanations.

Fomital, as from infected instruments, sponges, etc.

Indirect corporeal, as from the septic fingers of the nurse or medical attendant.

Prevention of Origin and Spread.—Notification; cleanliness; antiseptic midwifery; disuse of sponges, and the careful closure of all wounds.

The surroundings of the lying-in chamber must be hygienic. As long as the medical officer of health has no control over the midwives in his district, the prophylaxis of puerperal fever cannot be properly carried out. If midwives were required to obtain licences from the Local Authority, their actions could be controlled, and the medical officer of health could issue instructions to them as to the necessity for, and the method of obtaining, surgical and obstetrical cleanliness.

Relapsing Fever.

Syn., Famine Fever.

Geographical Distribution.—Great Britain and Ireland. It is known also in eastern Europe, Egypt, and India.

Etiology.—The disease is due to the *Spirochæte* or *Spirillum Obermeieri*, which is found in the blood only during the febrile stage and during relapses. Microscopically, it appears in the form of a fine thin spirillum like the outline of a saw edge, with pointed extremities, and possessed of extreme motility (Plate V. Fig. 6). There is no spore formation in the blood, though bright granules are often seen. The spirilla disappear from the blood during the non-febrile stage, and accumulate in the spleen, and possibly in the bone-marrow, where they are destroyed by the leucocytes. The spirillum has not been found in the secretions or excretions, nor has it been cultivated outside the body.

Staining.—The best stain is watery methylene-blue. It is decolorised by Gram's method.

Description.—The disease is inoculable into man and monkeys by the injection into them of blood containing the organism. Under such conditions the incubation period is three days.

The ordinary *incubation period* in man varies from four to ten days, and may even be more prolonged.

Symptoms.—There are no prodromata, the onset being very sudden, with rigors, giddiness, and high fever. Petechiæ and hæmorrhages are grave symptoms, as are also delirium and scanty urine. A rash is very rare, but has been described. The condition remains much the same for about a week, with joint and muscle pain and severe headache, and then there is a sudden crisis, with profuse sweating and disappearance of all the symptoms. This interval lasts another week, and a rigor again occurs on the fourteenth day, followed by a true relapse, shorter as a rule than the original attack. It ends in crisis, and there may or may not be further relapses, probably depending on the completeness of organismal destruction by the spleen. The total duration of the illness is, as a rule, six weeks.

Types.—Typical; typhoidal with jaundice; form with anuria.

Differential Diagnosis.—Distinguish from influenza, typhus, early smallpox, and malaria.

It is apt to occur along with epidemics of typhus.

Mortality.—Four per cent. in the British islands. Ten per cent. in India. It is highest in the aged and in the early periods of epidemics.

Incidence.—*Age.*—All ages are liable. It is most common in persons between 15 and 25.

Sex.—Males are more liable than females.

Season has no influence.

Race.—The Irish are peculiarly prone.

Recurrence.—One attack does not prevent a second.

Isolation has to be continued for six weeks.

Quarantine.—Fourteen days.

Methods of Transmission.—*Aerial*, the "striking distance" being short.

Fomital.—Laundry women are apt to contract the disease.

Direct corporeal, the most frequent method.

Indirect corporeal, as when a healthy person conveys the fever from a patient to another individual. The possible implication of blood-sucking insects, such as bed-bugs and mosquitoes, as carriers of the disease must be considered. A healthy monkey has been known to acquire the spirillum from a diseased monkey through the agency of a bed-bug.

Prevention of Origin and Spread. — Notification. Isolation in hospital. Quarantine. Danger from abraded skin has to be avoided by taking ordinary precautions. As relapsing fever is associated with famine, destitution, and overcrowding, these conditions must be remedied. Disinfection of buildings, discharges, fomites, and patients.

Rheumatic Fever.

Syn., Acute Rheumatism.

Geographical Distribution.—It is most common in temperate, subtropical, and humid climates.

Etiology.—Rheumatic fever is here included, because, though no proof has so far been adduced that it is a communicable disease, yet opinion is trending to the belief that the disease is due to some specific micro-organism possessed of toxine-forming powers, and possibly having a habitat in the soil. Both an anaerobic bacillus and a diplococcus have been found in the blood of living cases. The former, which resembles *B. enteritidis sporogenes*, is pathogenetic to rabbits (Achalme), and the latter, which is pleomorphic and both aerobic and anaerobic, produces in animals a disease resembling rheumatic fever (Poynton and Paine). Singer maintains that acute rheumatism is an attenuated pyæmia due to pyogenic cocci. Chill is a marked predisposing cause.

Description.—*Incubation period* unknown.

Symptoms.—The onset is usually gradual, and preceded by malaise and tonsillitis. Fever quickly supervenes, with evidence of arthritic and cardiac implication. Fibrous tissues become affected, and there is marked sweating and anæmia. The duration is variable, and relapses are common.

Differential Diagnosis.—Distinguish from pyæmia, the result of bone disease.

Mortality.—Slight, it is most fatal to children.

Incidence.—*Age.*—Adolescents and young adults are most frequently attacked.

Sex.—Considering all ages, males are more commonly attacked.

Season.—The autumn in this country. It is most frequent in dry years, when the subsoil water is low and the earth temperature high.

Recurrence.—One attack predisposes to a second.

Method of Transmission.—Unknown; probably *aerial* or *telluric*.

Prevention of Origin and Spread.—It has been suggested that rendering the basements of houses impermeable might diminish the prevalence of the disease.

Soft Sore.

Syn., Soft Chancre.

Geographical Distribution.—General.

Etiology.—It is due to an organism found in the sores and in their discharges, and appearing microscopically as small oval rods arranged in groups or short chains.

Cultural Characteristics.—Nil.

Staining.—It takes up the basic anilin dyes, but is readily decolorised.

Description.—The *incubation period* is a day or two.

Symptoms.—Soft sore is a contagious venereal sore of the nature of a spreading ulcer, and associated with bubo formation. It is almost solely confined to the genitals, and is often multiple. It is autoinoculable.

Types.—Simple, phagædenic, gangrenous.

Differential Diagnosis.—Distinguish from hard chancre and herpes.

Method of Transmission.—*Fomital* and *direct*.

Prevention of Origin and Spread.—As for gonorrhea (see p. 44).

Tetanus.

Syn., Lockjaw.

Geographical Distribution.—It occurs both in hot and temperate climates, though it is more common in the former, where it has been known to simulate an epidemic. There have been surprisingly few cases during the South African campaign.

Etiology.—It is due to the toxines of a specific organism found in the pus from infected wounds, its natural habitat being garden soil, dung-heaps, and dust, especially stable dust. It appears that the organism is much assisted in producing its toxine by the coincident presence of such other organisms as the pyogenic cocci and by a bruised condition of the tissues.

Microscopically, in culture preparations it appears as a slender rod with rounded ends occurring singly or in threads. It has slight motility, and possesses long flagella confined to the ends or general in distribution (Plate VI. Fig. 2). It readily forms spores, and then presents a typical appearance exactly like a Zulu knobkerrie or a drum-stick (Plate VI. Fig. 1).

Cultural Characteristics.—It is strictly anaerobic, and in stab cultures in glucose gelatine presents a feathery growth in the substance of the jelly, which is slowly liquefied, a burnt odour being produced along with slight gas formation (Fig. 12).

Staining.—It stains with the ordinary basic anilin dyes, and retains the stain in Gram's method. If spores are present, they often alone stain.

Description.—The disease affects horses, sheep, and cattle. In man, agricultural labourers, gardeners, and stable-workers.

The *incubation period* varies from one to twenty-one days.

Symptoms.—There are three stages—(*a*) Incubation, (*b*) local spasms, (*c*) general tetanic convulsions.

There are usually no premonitory symptoms, but there may be pain and discomfort at the seat of inoculation. The first sign is as a rule trismus of the neck and jaw muscles, giving rise to the facial expression known as "risus sardonicus." Tension of the abdominal muscles follows, and opisthotonos, absent during sleep. There is pain in the cramped muscles and general convulsions. The disease usually terminates in death between the third and seventh day, from exhaustion or suffocation, the intellect remaining clear to the last.

Fig. 12.—Stab culture, *B. tetani*, in glucose gelatine.

The symptoms are due to toxines circulating in the system. These, which are intensely poisonous in minute doses, are produced by the bacillus which remains confined to the seat of inoculation.

Types.—Acute and chronic; also traumatic, puerperal, neonatorum, and cephalic.

Differential Diagnosis.—Distinguish from hydrophobia, strychnine poisoning, tetany, hysteria, and hystero-epilepsy.

Mortality.—Between 80 and 90 per cent.

Incidence.—*Age.*—It is most frequent between the ages of 10 and 20 years.

Sex.—Both equally liable, though males are more often attacked.

Method of Transmission.—*Fomital*, as from infected instruments or dressings.

Telluric, as from infected soil contaminating wounds or abrasions.

Direct corporeal, as from an infected animal.

Prevention of Origin and Spread.—Cleanliness. Protection of the feet, especially in the case of children. Aseptic treatment of wounds, and antiseptic treatment of septic wounds. Avoidance of predisposing causes, such as drink and chill. Disinfection of discharges.

The injection of tetanus antitoxine, which is obtained from the blood serum of a horse, rendered immune by the repeated administration of the toxine of tetanus along with terchloride of iodine.

This procedure has not been very successful in the human subject, but is important in connection with veterinary work.

Tuberculosis.

Geographical Distribution.—World-wide.

Etiology.—The disease is due to the tubercle bacillus, which is found in the various lesions. Microscopically, though very pleomorphic, it usually appears as a thin rod, occurring singly or in groups. It is not motile, and, as far as is known, does not form spores, but in its powers of resistance it approximates to the spore-forming bacteria. It retains its vitality even in the presence of the putrefactive organisms, and is not killed by the X-rays, but sunlight is inimical to it. In all probability it is a form of streptothrix, and may exhibit clubbing.

Cultural Characteristics.—It grows best on blood serum, and if so cultivated will afterwards flourish on almost any medium. On serum, growth is slow, and appears in from ten to fourteen days as small, dull white points raised above the surface. In subculture its aspect is more typical, namely, a white and wrinkled film like an old man's skin (Fig. 13).

Staining.—It stains slowly with the ordinary stains, and best with carbol fuchsin. For demonstration in tissues, sputum, or discharges, the Ziehl-Neelsen contrast stain is generally employed (Plate VI. Fig. 3).

Fig. 13.—*B. tuberculosis hominis;* four weeks' growth on glycerine agar.

Description.—The disease affects cattle, pigs, fowls, rabbits, and guinea-pigs.

The *incubation period* is as a rule prolonged and uncertain.

Symptoms.—Tuberculosis may be either acute or chronic, and is one of the granulomata. It consists in an inflammatory infiltration of the tissues of, it may be, every system in the body, spreading by the lymphatics as a rule, and tending to proceed to caseation, disintegration, and suppuration. Fever, hectic, and debility accompany the special manifestations characterising the site of the disease.

Types.—Acute, chronic.

Differential Diagnosis.—Distinguish from chronic febrile disorders associated with marasmus and also from various forms of neoplasm and abscess formation.

Mortality.—The acute type is very fatal, the chronic not so deadly, the result depending largely on treatment. One-seventh of the world's total deaths is due to tubercle.

Incidence.—*Age.*—All ages are liable. Alimentary tubercle has its chief incidence on children. Respiratory and other varieties tend specially to attack young adults.

Sex.—There is no preference shown.

Season.—In this country it is most prevalent in winter and spring.

Race.—All races are liable.

Climate.—It prevails especially in countries with variable temperatures, much humidity, cold winds, and damp soils. There is less tubercle in elevated regions than in lowlands.

Isolation.—The need of isolation is becoming more and more apparent.

Method of Transmission.—*Aerial,* as from the inhalation of air infected by the dried sputum and discharges containing the organism.

Alimental, as from the milk of tuberculous cows, butter and cheese made from such milk, and the meat of tuberculous cattle. Koch has recently thrown doubts on the existence of this method of transmission (see p. 229), but at present the belief should neither be discarded nor the precautions consequent upon it disregarded or relaxed.

Fomital, which is really aerial in nature.

Direct corporeal, as seen in phthisis, where a patient may infect another individual by coughing, the virus passing directly from one to the other. Also by inoculation of wounds, etc., with tubercular matter.

Indirect corporeal, as from flies or other insects conveying the poison. Strictly speaking, tuberculosis is not hereditary, but persons may inherit a constitution peculiarly liable to the disease.

Prevention of Origin and Spread.—Notification of tuberculosis is a procedure not as yet in general use, and the value of which has been much debated, owing to the divers forms in which the disease occurs and its great prevalence. Such a measure would consequently entail heavy expense. Notification alone will not prevent the spread of tubercle, but it enables other important preventive measures, such as isolation, disinfection, and the improvement of house accommodation, to be put in force. With such an aim in view, notification, either voluntary or compulsory, is urgently required, but all forms of tuberculosis need not be notified. Its special value is seen in the opportunity it gives a medical officer of health to remove to hospital advanced cases of phthisis which form foci for the spread of the disease. Edinburgh proposes to provide hospital accommodation for these *causæ causantes*, one hundred beds being set aside in a special building for this purpose. In commencing the notification of tubercle, it would probably be wise to limit it to its most dangerous and most communicable form, phthisis pulmonalis. It is quite unnecessary to go to the expense of notifying tubercle of the bones and glands. Notification of phthisis is compulsory in New York, and has yielded most satisfactory results.

Isolation.—The establishment of sanatoria for the open-air treatment of the disease, especially in the case of pulmonary tubercle in its earlier stages. Patients discharged from sanatoria might with advantage form "tuberculous colonies," where they could undertake outdoor occupations and live under good hygienic conditions (Philip). As stated above, the segregation of advanced cases. General cleanliness is of the highest importance in houses occupied by the victims of tuberculosis.

Disinfection of buildings, fomites, sputum, and discharges.

The use of spit-boxes and paper-mouchoirs which can be burnt, the former containing an efficient antiseptic, such as carbolic acid. No phthisical patient should spit anywhere but into his own spit-box.

Such efficient inspection of milch cows as will prevent any individual animal suffering from tubercle, either in the udder or elsewhere, being used to provide milk for human or animal consumption. Further, a system of supervising dairies to prevent accidental infection of good milk with the tubercular virus; for example, the exclusion of phthisical persons from dairy-work, and the storing of milk under such hygienic conditions as will tend to maintain its purity unimpaired. Boiling renders tubercular milk safe, so that milk derived from any doubtful source should be sterilised before use. This, however, must merely be regarded as a supplementary precaution, and should be rendered unnecessary by the methods detailed above.

Meat may be itself diseased, or may be infected from a knife used to cut up tuberculous carcases. Dangers in this direction are to be obviated by the proper inspection of slaughter-houses, and of all animals and meat intended for human food. Infected animals and carcases must be condemned, and it is to be noted that ordinary cooking of tubercular meat does not render it sterile. Private abattoirs should be abolished. Tuberculin, a substance derived from the artificial cultivation of tubercle bacilli, is used with success as a diagnostic agent in the case of suspected cattle.

The recommendations of the Tubercle Commission regarding this and other important points will be found detailed on p. 227, 230. There is a pernicious habit of giving employment to phthisical persons, especially women, in the tripe-dressing department of slaughter-houses, as their health benefits from the nature of the work. This should not be permitted, as it may constitute a danger to the consumers.

The proper ventilation and sanitation of all byres, milk shops, dairies, and abattoirs.

There can be no doubt that persons the victims of tubercle should not marry; but at the present time no restrictions are imposed by law, save in certain of the United States. A mother suffering from tuberculosis should on no account suckle her offspring. In the United States expectoration in public conveyances is strictly forbidden, and heavy fine or imprisonment await the spitter. In Sydney the "street spitter" is fined £1 for each offence. Further, a law has recently been passed prohibiting the entrance into the United States of aliens suffering from tuberculosis.

General Methods.—Proper ventilation, supplying abundance of fresh air and sunlight, and the prevention of overcrowding, dampness, and alcoholism. A tubercular patient should not share a bed or a room with any non-tuberculous individual. Good food, sanitary dwellings, proper clothing, and the regulation of trades conducted in dust-laden or foul air are all means whereby tuberculosis may be combated. It would be well if Public Health authorities were to undertake the duties of disinfection, aiding diagnosis by bacteriological examination, and of generally endeavouring to prevent the spread of this deadly disorder by disseminating information regarding it.

Veldt Sore.

Geographical Distribution.—South Africa.

Etiology.—Unknown, though a micrococcus has been described as the cause, and the disease is doubtless due to an organism. Some believe it to be a staphylococcal infection.

Description.—These sores occur chiefly on the backs of the fingers, hands, and wrists, but also affect the face, feet, and preferably the extensor surfaces of the legs, though other parts of the body are not immune. They begin as small, itchy papules, which become vesicles. An open sore results, spreading in a diffuse vesicular form, and tending to heal at the centre, where the skin becomes red, thickened, and glazed-looking. A scar, often pigmented, results, and though there is not much discharge, the sores are autoinoculable.

Incidence.—*Season.*—The sores are prevalent all the year round.

Race.—Natives of South Africa, white and black, are exempt. Fair-skinned men are said to be more liable.

Method of Transmission.—The probability is that infection takes place through the agency of some insect, such as a house-fly, horse-fly, or tick. It is said that men working with horses are more apt to contract these sores. As yet it is undecided whether an abraded surface is necessary for infection.

Prevention of Origin and Spread.—Cleanliness and protection of exposed parts. Care of wounds and abrasions.

PLATE VI.

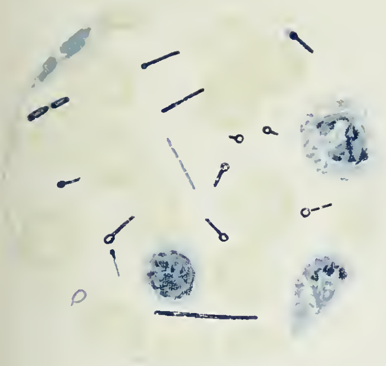


Fig 1.

Fig 2

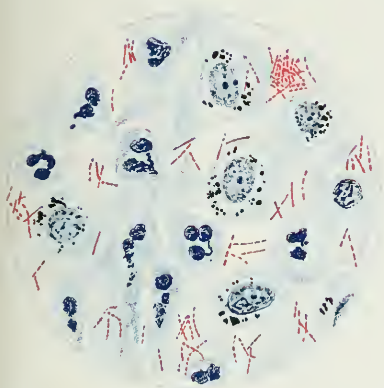


Fig 3.

Fig 4

Fig 5.

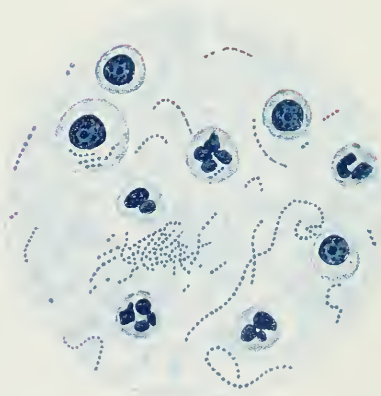


Fig 6

FIGURE 1.—*B. Tetani*, with spores, scraping from wound (× 1000 diam.). Thionin blue.
„ 2.—*B. Tetani*, showing flagella, 24 hours culture (×1000 diam.). Muir's method.
„ 3.—*Tubercle bacilli* in phthisical sputum (× 1000 diam.). Ziehl-Nielsen contrast stain.
„ 4.—*B. Icteroides* agar culture (× 1000 diam.). Fuchsin.
„ 5.—*B. Enteritidis Sporogenes*, showing spores (× 1000 diam.). Carbol fuchsin and meth. blue.
„ 6.—*Milk from inflamed udder of cow.* Streptococcal infection (× 1000 diam.).

Verruga.

Geographical Distribution.—It is an endemic disease occurring at high altitudes on the western slope of the Andes range in South America.

Etiology.—Unknown, but possibly a parasitic worm.

Description.—Domestic animals are subject to the disease.

The *incubation period* is from fourteen to forty days.

Symptoms.—There is an onset with fever like malaria and gastric disturbances, associated with severe pain in the bones, muscles, and diaphragm. These symptoms last with remissions for from one to twelve months, and are followed by a characteristic eruption of two kinds—

(*a*) Cutaneous, consisting of raised red vascular spots of a warty nature. They may grow to a considerable size, and are very itchy. If uninjured, they darken and finally vanish, leaving no scars. Similar growths may affect mucous membranes.

(*b*) Subcutaneous, appearing as hard movable tumours, over which the skin often gives way, leaving exposed fungoid growths with foul discharges.

The eruption is most common on the face and extremities.

The disease produces profound anæmia and debility, and may end in death, the result of hæmorrhage from the skin lesions, which are very liable to bleed, especially when the barometric pressure is low. Cold aggravates the constitutional symptoms.

Differential Diagnosis.—Distinguish from yaws, and in its early stages from malaria.

Mortality.—Varies from 10 to 40 per cent. It is highest in the white races and in some epidemics.

Incidence.—There is nothing to note regarding incidence.

Recurrence.—One attack confers immunity.

Method of Transmission.—Uncertain; possibly *alimental* or *telluric*, as the disease may be due to a parasite whose external habitat is water or soil.

Prevention of Origin and Spread.—Removal to a warm region at sea-level. Until the etiology is more fully known, other methods must be confined to general hygienic precautions, such as procuring a good water supply, etc.

Weil's Disease.

This is a rare disorder of the nature of an acute febrile icterus, said to be due to the *B. proteus fluorescens*.

Whooping Cough.

Syn., Pertussis.

Geographical Distribution.—It is a wide-spread epidemic disease, occurring especially in temperate climates.

Etiology.—Unknown; various organisms have been described.

Description.—Dogs are liable to the disease.

The *incubation period* is usually fourteen days, but may be less.

Symptoms.—There are premonitory catarrhal symptoms, during which the disease is communicable, and which are followed by the typical spasmodic cough occurring in violent paroxysms during a period of from two to ten weeks, and gradually subsiding.

Differential Diagnosis.—Distinguish from laryngismus stridulus, croup, bronchial catarrh, and asthma.

Mortality.—It is very fatal to infants and the negro races. The average mortality is 2 to 5 per cent.

Incidence.—*Age.*—It is a disease of infants and of young children of from 1 to 8 years of age. Adults, however, are not exempt.

Sex.—Females are more liable.

Season.—It is more prevalent in spring and autumn, and is favoured by cold and damp.

Isolation should be continued for six weeks.

Quarantine.—Fourteen days.

Method of Transmission. — *Aerial, fomital, direct corporeal, indirect corporeal*, as from conveyance of the virus by a healthy person.

Prevention of Origin and Spread.—Notification; isolation; quarantine; pamphlet distribution; disinfection of buildings, fomites, and discharges, all rags used for the last-named being burned; the use of antiseptic sprays and irrigation of the nostrils.

Free ventilation and access to fresh air are of the first importance. The question of school closure may occasionally require consideration.

Yaws.

Syn., Frambœsia.

Geographical Distribution.—Yaws is a widely distributed disease of the tropics. It is endemic in Africa.

Etiology.—It is probably unknown. Yaws is said to be due to a micrococcus which has been cultivated, but concerning which definite proof is lacking, the lower animals being insusceptible to the disease. The organism is found in the secretions from the tumours and in the tissues of infected persons. It also occurs in the dust of houses.

Cultural Characteristics.—It grows well on blood serum.

Description.—The *incubation period* varies from two weeks to six months.

Symptoms.—There is initial fever with headache and pains in the bones and joints, followed by an eruption commencing as scurfy patches in which papules appear. These papules enlarge and form the typical yaws, which are tubercles varying much in size, and which tend to shrivel up and disappear after several weeks, leaving pigmented patches which gradually fade. The tumours, which occur in successive crops, may, however, break down and ulcerate, the ulcers remaining limited or spreading to the surrounding tissues. The yaws are most frequent on the exposed parts of the body, and the disease may last for weeks, months, or years, and is followed by sequelæ similar to the lesions seen in tertiary syphilis, and regarded by some as due to a previous syphilitic infection.

Types.—Ulcerative, non-ulcerative.

Differential Diagnosis.—Distinguish from syphilis, oriental sore, tuberculous leprosy, and verruga.

Mortality.—Trifling, about 2 to 5 per cent.

Incidence.—Age.—No age is exempt. It is more common before puberty.

Sex.—Yaws is three times more common in males than in females.

Season has no influence, but outbreaks tend to follow heavy rains.

Race.—No race is exempt, but negroes are specially liable.

Recurrence.—One attack may or may not confer immunity.

Isolation.—Special hospitals for yaws are established in the West Indies, and isolation is enforced.

Quarantine is impracticable.

Method of Transmission. — The disease is neither congenital nor hereditary. *Fomital, direct corporeal, indirect corporeal.* An abraded surface is necessary for the acquisition of the disease. Sexual intercourse and the suckling of children are examples of the direct corporeal method, while the conveyance of the virus by flies and other insects exemplifies the indirect corporeal method.

It is possible that the virus may be water-borne, in which case the term *alimental* would have to be added to the category.

Prevention of Origin and Spread.—Notification is desirable. Isolation. Compulsory segregation of the infected sick in special hospitals or wards is required.

Destruction of mean, infected dwellings and fomites of no value.

Disinfection of buildings, fomites, discharges, and patients.

Care of abrasions and wounds in those brought into contact with patients.

Infants should not be suckled by mothers suffering from yaws, although the virus is not secreted in the milk itself.

Prevention of pollution of bathing water.

It is interesting to note that inoculation and intentional exposure of children to infection are practised amongst races subject to yaws. The custom is prevalent in Fiji.

Yellow Fever.

Geographical Distribution.—It is endemic in three areas, namely, the West Indies and Mexico, Brazil, the Senegambia coast of Africa. From these areas it has spread as an epidemic into other parts of Africa, the United States, Europe, etc. As a rule, yellow fever is a disease of the sea-coast, and especially sea-coast towns, and of river deltas.

Etiology.—It has been attributed to various organisms, that most worthy of consideration being the *B. icteroides* of Sanarelli. It occurs sparsely in the blood and tissues, especially the liver, but is not found in the intestinal tract, and it produces a most virulent toxine, the so-called amaril poison. The bacillus is very resistant to dry heat, but dies in water at a temperature of 60° C. It is killed in seven hours by solar rays, but lives for a long time in sea water. Microscopically, it is a slender, motile, and flagellated rod (Plate VI. Fig. 4).

Cultural Characteristics.—It is a facultative anaerobe which grows on ordinary media, produces gas, and does not coagulate milk. On gelatine plates it forms transparent granular colonies, which become opaque and do not liquefy the medium. A tiny "milk drop" appearance is produced on stroke gelatine. On agar at 37° C. the colonies are not characteristic; but if grown at

20° to 22° C., or if taken from the incubator at 22° C. within twelve hours, and kept at room temperature, a "milk drop" form develops, and finally colonies with transparent centres and opaque margins appear, a sufficiently characteristic appearance (Fig. 14). This shows the contrast between the two zones, but for purposes of demonstration the clear centre is represented dark. The presence of moulds undoubtedly aids the growth of the bacillus in culture media.

Staining.—It is decolorised by Gram's method.

Filtered cultures injected into five men were said to produce yellow fever, thus showing that it is the toxine and not the organism which is responsible for the symptoms. It is pathogenetic to domestic animals.

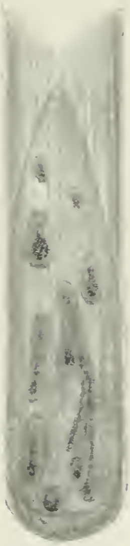


Fig. 14.—*B. icteroides* culture on agar, incubated at two different temperatures, 37° C. and 20° C. (Sanarelli).

More recently Durham and Meyers have described a fine, small bacillus found in the intestine and elsewhere, and which is very difficult to stain.

It is possible that some form of protozoon may be the cause, as observation and experiment go to prove that the mosquito can convey the virus from man to man. The whole question is at present sub judice, and though protozoa have been looked for they have not been found.

Description.—Yellow fever may be said to be a disease of low-lying littorals.

The *incubation period* varies from a few hours to thirty days. It is usually two to five days.

Symptoms.—There is initial fever lasting from three to four days, accompanied by severe headache, bilious vomiting, pain in the loins, albuminuria and constitutional disturbance, followed by an adynamic period, which may end in recovery, or may pass on to a stage of reaction characterised by hæmatemesis (black vomit), hæmaturia, jaundice, and ending in death by coma or exhaustion.

Mild cases may recover in a week; more severe cases last a fortnight to three weeks, and convalescence is often prolonged and interrupted by relapses.

Types.—Mild, severe, grave, and anomalous, *i.e.* apoplectic, algid, choleraic.

Differential Diagnosis.—Distinguish from malaria, black-water fever, dengue, relapsing fever, and febricula.

Mortality.—The average in the unacclimatised is from 25 to 30 per cent. It may be as high as 80 per cent. In the acclimatised it varies from 7 to 10 per cent. Different epidemics vary in severity, and the same epidemic is more fatal at one time than at another. The disease claims most victims amongst males.

Incidence.—*Age.*—Adults are more commonly attacked.

Sex.—Males are more liable.

Season.—The rainy season favours the fever. The temperature must be over 75° F. for epidemics to develop. The disease may remain latent in a town during the winter.

Race.—The white races are most susceptible, then the yellow, and lastly the black. If a negro is attacked he usually has the disease in a mild form.

Recurrence.—There is, as a rule, lifelong immunity. In this connection it should be noted that long residence in the endemic zone confers immunity, which is lost by absence from it in proportion to the period lapsed since leaving.

Isolation should be continued for from three to four weeks.

Quarantine.—Ten days.

Method of Transmission.—*Aerial*, aided by the presence of moulds.

Fomital, though recent experiments have thrown some doubt on this method.

Indirect corporeal, as from conveyance by means of the mosquito, variety *Culex fasciatus*, and by healthy persons. On a large scale it is diffused by maritime commerce. It would appear that the organism requires a certain environment for its development, either an intermediate host or some "place" condition favourable to its extracorporeal life. Thus it is safe to visit a yellow fever patient who has been removed from the endemic focus, provided the spot to which he has been conveyed does not itself become an endemic focus.

Prevention of Origin and Spread.—Notification; isolation, preferably in hospital; quarantine.

Emigration of unacclimatised from the endemic zone.

In localities where the disease is not endemic, establishment of quarantine camps, and rigid isolation of the infected area.

Prevention of susceptible persons entering the affected area.

In the case of seaports, prohibition of sailors landing from ships. The application of the Local Government Board cholera, etc., orders in cases of infected ships (see p. 537).

In cases of ships with fever cases breaking out on board them at sea or in port, the sick, if possible, should be landed, and the vessel steered for cold latitudes.

The remedying of defective sanitation and overcrowding. Thorough ventilation, which gets rid of moulds, and is especially important in the case of ships.

Destruction or disinfection of fomites. In the light of recent research this may be unnecessary.

Disinfection of buildings, ships, discharges, and patients.

The disuse of ground floors as dwelling-rooms, because yellow fever, like plague, is said "not to go upstairs."

As there seems little doubt that the mosquito can convey the virus, precautions somewhat similar to those employed in malaria may yet have to be put in force where yellow fever is endemic.

[Table.

PERIODS OF INCUBATION, ISOLATION, AND QUARANTINE OF CONTACTS IN THE COMMUNICABLE DISEASES.

Disease.	Incubation Period.	Isolation Period.	Quarantine of Contacts.
Anthrax . . .	About 48 hrs.; variable.	...	...
Beri-beri . . .	1 month.	...	...
Cerebro-spinal fever .	2–7 days.	14 days.	...
Cholera . . .	A few hours to 10 days.	Till discharges free from specific organism.	10 days.
Dengue . . .	4 days.	14 days.	...
Diarrhœa epidemica .	A few hours to 2 days.	...	...
Diphtheria . . .	2–7 days.	3 weeks after symptoms cease.	10 days.
Dysentery . . .	A few hours to 7 days.	Till stools are normal.	...
Enteric fever . .	12–14 days.	As for cholera.	...
Erysipelas . . .	1–7 ,,	Till end of fever.	...
Foot and mouth disease	3–5 ,,	...	...
"Fourth disease" .	9–21 ,,	14–21 days.	23 days.
Glanders . . .	24–48 hours.	...	...
Glandular fever . .	7 days.	3 weeks.	7 days.
Gonorrhea . . .	2–3 days.	...	...
Hydrophobia . .	7 days to 2 years.	...	...
Influenza . . .	A few hours to several days.	1 week.	...
Leprosy . . .	A few weeks to several years.	Prolonged.	...
Malaria . . .	1 week to 10 days.	...	...
Malta fever . . .	3–15 days.	..	...
Measles . . .	12–14 days usually.	21 days.	16 days.
Mumps . . .	1–3 weeks.	3 weeks.	3½ weeks.
Plague . . .	2–8 days usually.	6–8 weeks.	8–12 days.
Pneumonia epidemica .	18 or 36 hours to 5 days.	A fortnight.	7 ,,
Puerperal fever . .	1–3 days.	...	...
Relapsing fever . .	4–10 ,,	6 weeks.	14 days.
Rubeola . . .	9–22 ,,	21 days.	23 ,,
Scarlet fever . .	12 hours to 7 days.	Till cessation of desquamation and discharges: usually 7 weeks.	7 ,,
Soft sore . . .	1–2 days.	...	...
Syphilis . . .	3 weeks.	...	...
Tetanus . . .	1–21 days.	...	...
Typhus fever . .	12 ,,	5 weeks.	14–16 days.
Vaccinia . . .	3 ,,	...	...
Varicella . . .	11–19 ,,	3–4 weeks.	18–21 days.
Variola . . .	11–14 ,,	Till separation of crusts; usually 6 weeks.	17 ,,
Verruga . . .	14–40 ,,	...	...
Whooping-cough . .	12–14 ,,	6 weeks	14 days.
Yaws	4 weeks to 6 months.	Prolonged.	...
Yellow fever . .	A few hours to 30 days; usually 2–5 days.	3–4 weeks.	10 days.

II. PARASITIC DISEASES.

For purposes of classification, the parasites of man are conveniently considered according to the system they affect.

1. Alimentary System.

Trichomonas oris.
Oidium albicans.
Leptothrix.
Achorion Schönleinii.
Filaria labialis.
F. hominis oris.
Coccidia.
Monas pyophila.
Lamblia intestinalis.
Balantidium coli.
Distoma hepaticum.
D. lanceolatum.
D. conjunctum.
D. sinense.
D. crassum.
D. ringeri.
Tænia echinococcus.
Pentastoma tænioides.
P. constrictum.
Trichomonas intestinale.
Tænia mediocanellata.
T. solium.
T. nana.
T. cucumerina.
T. flavo-punctata.
T. madagascariensis.
Bothriocephalus latus.
B. cordatus.
B. cristatus.
Ascaris lumbricoides.
Oxyuris vermicularis.
Ascaris mystax.
A. maritima.
Ankylostomum duodenale.
Trichocephalus dispar.
Trichina spiralis.
Rhabdonema intestinale.
Strongylus subtilis.
Distoma heterophyes.
Insecta.

2. Hæmopoietic System.

Tænia echinococcus.
Filaria sanguinis hominis.
F. diurna.
F. nocturna.
F. perstans.
F. demarquaii.
F. lymphatica.
F. volvulus.
F. restiformis.
F. inermis.
F. magelhæsi.
F. ozzardi.
Bilharzia hæmatobia.

3. Respiratory System.

Aspergillus niger.
Distomum ringeri.
Tænia echinococcus.
Strongylus longivaginatus.
Lucilia hominivora.
Sarcophaga carnaria.
Pentastomum denticulatum.
P. constrictum.
Suctoria.

4. Urinary System.

Plagiomonas irregularis.
Bilharzia hæmatobia.
Tænia echinococcus.
Eustrongylus gigas.

5. Nervous System.

Tænia echinococcus.
T. acanthotrias.
Filaria oculi humani.
Distomum ophthalmobium.
D. ringeri.

6. Locomotory System.

Miescher's tubes.
Tænia acanthotrias.
Trichina spiralis.

7. Serous Cavities.

Bothriocephalus mansonii.
Tænia echinococcus.

8. Connective Tissue.

Filaria loa.
F. medinensis.

9. Reproductive System.

Trichomonas vaginalis.

10. Integumentary System.

Aspergillus niger.
Achorion Schönleinii.
Microsporon furfur.
M. audouini.
Trichophyton megalosporon endothrix.
T. megalosporon ectothrix.
Rhabditis niellyi.
Filaria medinensis.
Pinta and piedra (diseases).
Cuterebra noxialis.
Ochromyia anthropophaga.
Gnats and mosquitoes.
Pulex penetrans.
Pediculus.
Pulex irritans.
Acarus scabiei.
Demodex folliculorum.
Ixodes.
Hæmadipsia Ceylonica.

I. ALIMENTARY SYSTEM.

(a) ORAL.

INFUSORIA.

Trichomonas oris.—A flagellated infusorian found in the human mouth. The varieties *cordata* and *elongatus* also occur.

Oidium albicans, or Thrush, better called Endomyces.—A vegetable parasite of the nature of a fungus, confined to parts covered by squamous epithelium, and specially found in the mouth and fauces of infants and young children, when the buccal secretions are acid in reaction. This condition may arise owing to an excess of mucus over normal saliva, the former more readily turning acid. The parasite is probably closely allied to, if not identical with, the oidium lactis, one of the organisms which causes souring of milk. In the mouth, aphthous patches are found, the milk-white flakes being composed of the spores and mycelium of the fungus mingled with dead squamous epithelium (Fig. 15).

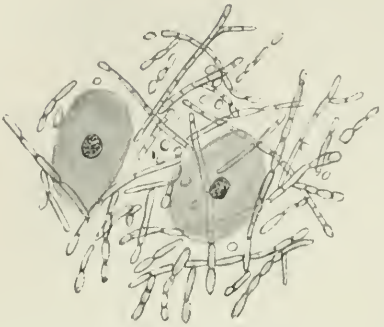


Fig. 15.—*Oidium albicans*, thrush fungus from mouth, × 200 diameters.

Leptothrix.—This is one of the highest forms of bacteria normally present in the human saliva. Occasionally it obtains a lodgment in the tonsils, appearing in the form of little horny, yellowish white masses, occupying the follicles, and being frequently arranged in a crescentic or circular manner. It causes pricking and dryness of the throat. Microscopically, it appears as long filaments with terminal gonidia. The protoplasm does not contain sulphur granules.

NEMATODA.

Filaria labialis and **F. hominis oris** are rare forms of nematode worms, occasionally occurring in man.

(*b*) GASTRIC.

In the stomach cavity, *Ascaris lumbricoides*, *Oxyuris vermicularis*, and various larvæ of parasites have been found. In the stomach walls, favus, actinomycosis, and anthrax have occurred. These have been already discussed, or will be more fully considered at a later period.

(*c*) HEPATIC.

GREGARINIDÆ, COCCIDIA.

These, though common in the rabbit, are very rare in man. They appear in the liver substance as multiple opaque white nodules which microscopically contain capsulated bodies composed of granular protoplasm, at first homogeneous, but which later forms oval sperms. The capsule has a double contour, and is highly refractile. They are present in the fæces of the rabbit, but their mode of access to other rabbits or to man is unknown.

INFUSORIA.

Monas pyophila, a flagellate organism, has once been described in the pus from a liver abscess.

VERMES, TREMATODA.

Distomum hepaticum (*Fasciola hepatica*).—The liver fluke. This is a parasite living in the gall-bladder and bile ducts of the sheep and ox, and is sometimes found in man. It is a leaf-shaped hermaphrodite worm from $\frac{1}{2}$ to $\frac{3}{4}$ in. in length, and about $\frac{1}{8}$ to $\frac{1}{3}$ in. in breadth (Fig. 16). It produces eggs (Fig. 17) which are voided in the fæces, and thereby reach water or damp soil. After a varying time a ciliated embryo escapes from the ovum and makes its way into a small mollusc, in the pulmonary cavity of which it undergoes further development. At this stage it may pass with the mollusc into sheep or cattle, or it may leave its intermediate host, and, while free in water, or encysted on a water plant, gain entrance to the stomach of its host, be it sheep, cattle, or man, hence one of the dangers of eating uncleaned water-cress. It causes liver enlargement and its usual sequelæ, diarrhœa, sometimes vomiting, fever, marasmus, and often death. In sheep the disease is known as "rot."

Other liver trematodes occasionally occur in man, such as *D. lanceolatum*, *D. conjunctum*, *D. sinense*, *D. crassum*, *D. ringeri* (see p. 95).

Fig. 16.—*Distomum hepaticum*, liver fluke, × 3 diameters.

CESTODA.

Tænia echinococcus.—This is a hermaphrodite worm whose natural host is the dog, but whose intermediate host may be man, and many other animals, including the sheep, ox, or pig. The parasite lives in the intestine of the dog, and is a short worm of three or four segments, the terminal one containing the ova (Fig. 18, *a*). When ripe the terminal proglottis is extruded with the fæces, and, its walls decaying, the eggs are set free.

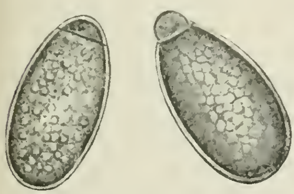


Fig. 17.—Ova of *D. hepaticum*, liver fluke, × 200 diameters.

These have now to reach their intermediate host. They are absorbed along with drinking-water, herbage, etc. From the stomach of the intermediate host the embryo, having developed six hooklets, bores its way into various tissues of the body, especially the liver, and becomes encysted. The resulting cyst (Fig. 18, *b*) is the hydatid, and its fluid is non-albuminous. This cyst is lined by a germinal layer, on which small elevations appear, which become hollow, and are the brood capsules. From the wall of a brood capsule the head or scolex grows and develops its suckers and hooks (Fig. 18, *c* and *e*). A large number of heads may be found in one brood capsule. There is thus a large cyst containing brood capsules, which in their turn contain scolices. In addition, from the outer, or more commonly the inner layer of the large cyst, daughter cysts are formed, which in structure are similar to the large cyst itself, and, like it, may produce brood capsules containing heads.

These large cysts and the daughter cysts may burst and set free the brood capsules and heads, which are extruded in the fæces. In their turn the heads are set free from the brood capsules, and may thus gain access to the dog (Fig. 18, *d*). They may also reach the dog after the death of the intermediate hosts, if the tissue in which they lie be devoured, or if in any other manner they reach the dog's food. In the dog's intestine the heads develop into the adult worm in a period of from four to eight weeks.

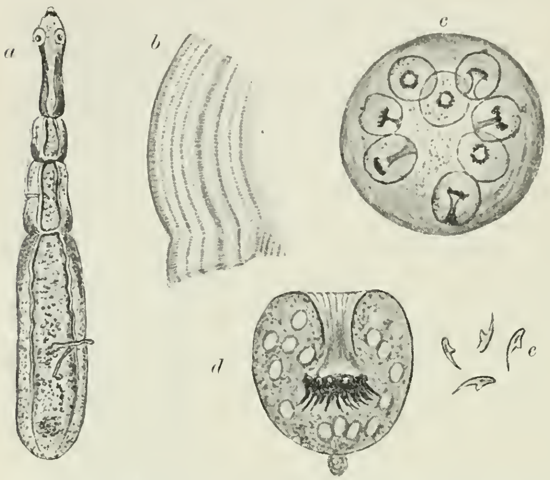


FIG. 18.—*a*, *Tænia echinococcus*, × 10 diameters. *b*, Ectocyst, hydatid membrane, × 200 diameters. *c*, Brood cyst, containing scolices, × 50 diameters. *d*, Scolex, retracted, × 200 diameters. *e*, Hooklets, × 200 diameters.

Hydatid of liver.

Geographical Distribution.—Hydatids are common in Iceland and Australia. No country, however, is exempt, but the disease is rarer in Scotland than in England.

Symptoms.—These vary with the position of the cyst.

Differential Diagnosis.—Distinguish from waxy disease, cancer, tropical abscess, nutmeg liver, cirrhosis, distended gall-bladder, and simple cyst. Also from hydronephrosis, right pleural effusion, hydatid of right lung, ascites, ovarian tumour, and phantom tumour.

Incidence.—*Age.*—It may occur at any age.

Sex.—In most places more males are affected than females, but in Iceland the reverse obtains.

Mortality.—It increases up to fifty years, but declines at later ages.

Method of Transmission.—*Alimental.*—The parasite in the form of the terminal proglottis, or as the free ova, is usually absorbed by man in drinking-water which has been fouled by the fæces of a dog infested with the worm. Raw vegetables not duly cleansed may also serve to convey the disease. There is no evidence that the ingestion of meat containing the hydatid cysts can produce hydatids in man.

Fondling of dogs may directly result in transference of the parasite.

Prevention of Origin and Spread.—A pure water supply from a good source. Proper preparation of vegetables, cress, etc., used for human food. Destruction of stray and foul-feeding dogs. Avoidance of fondling dogs.

ARACHNIDA.

Pentastoma tænioides.—The larva of this mite, known as *P. denticulatum*, has frequently been found in the human liver. The adult form inhabits the nasal chamber of the dog.

P. constrictum is the larval form of an arachnoid whose adult form is known. It occurs encysted in the liver.

Geographical Distribution.—Egypt, the Soudan, and the West Coast of Africa.

(*d*) INTESTINAL.

INFUSORIA.

Trichomonas intestinale is sometimes found in diarrhœic stools. Other forms are common and unimportant.

VERMES, CESTODA.

Tænia mediocanellata.—This hermaphrodite tapeworm is a common parasite of man, who forms its host, its cyst stage being passed usually in the ox, which therefore forms its intermediate host.

There is usually only a single *T. mediocanellata* present in the human intestine at one time. The worm is very long, from 12 to 24 ft., and its small head, though unadorned by hooklets or a rostellum, possesses four well-marked suckers (Fig. 19). The proglottides vary in shape and size from the head towards the tail, the smallest being towards the cephalic ends, and the broadest in the centre. These segments contain the many-branched uterus and the ova, those at the distal end being the most mature (Fig. 20, *a*). When ripe, they are cast off, and escape from the host's body by their own movements, or are expelled along with the fæces. They may then discharge their eggs either through the marginal pore by a rupture in the fore part of the uterus, or as a result of general decomposition, or the ova may not be set free till the segments have been ingested by the intermediate host. Each oval egg (Fig. 20, *b*) contains an embryo, and the egg-shell has to be dissolved by the digestive juices before the six-hooked embryo is liberated. By aid of its hooks the embryo bores its way through the tissues till it reaches muscular substance, where it promptly discards its hooks,

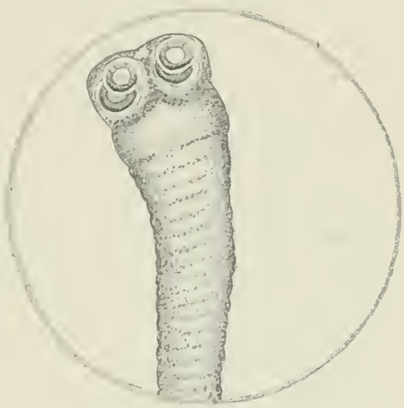


Fig. 19.—Head and immature segments of *Tænia mediocanellata*, × 12 diameters.

Fig. 20.—*a*, Segment of *T. mediocanellata*, × 5 diameters. *b*, Ova, × 200 diameters.

passes through an encysted stage (*Cysticercus bovis*), and develops a head at the opposite end from that which bore the hooklets. This head is an exact replica of the head of the mature worm. There is thus a round dropsical body, in which lie a head and long neck that can be protruded and retracted.

If now a human being devours the affected muscle, raw or insufficiently cooked, the bladder is digested, and the head, attaching itself by its four suckers to the mucous membrane of the intestine, becomes the mature tapeworm.

If not ingested, the cysticercus may retain its vitality for a lengthy period, or may die, wither, and calcify.

Geographical Distribution.—Southern France, Eastern Europe, parts of India and Africa, especially Abyssinia.

History in Host.—Sixty days elapse from the time the cysticercus is swallowed by man till the appearance of the proglottides in the stools or at the anus. Thereafter segments continue to be thrown off for several years, and are usually found singly and not of necessity in the fæces, as by virtue

Fig. 21.—Head, *Tænia solium*, × 30 diameters.

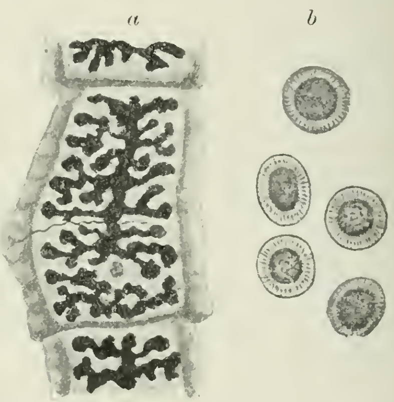


Fig. 22.—*a*, Segment of *T. solium*, × 5 diameters. *b*, Ova, × 200 diameters.

of their own movement they can leave the bowel, and may thus be discovered on the skin surface, or in the clothes, bed, etc.

Prevention of Origin and Spread.—Inspection of meat, and condemnation of "measly" beef, *i.e.* beef containing the encysted embryo. Efficient cooking of meat. Cleanliness in the person of the host. The administration of anthelmintics and microscopical search for the head.

Tænia solium.—This hermaphrodite tapeworm also passes its mature stage in the human intestine, its intermediate host being frequently the pig, and occasionally man himself. There may be several mature worms inhabiting the host at one and the same time. The tænia is 9 to 10 ft. in length, and its head possesses four suckers and twenty-six to twenty-eight hooklets grouped round the rostellum or beak (Fig. 21). The general arrangement of its segments resembles that of the mediocanellata, the mature proglottides being the distal and the longest (Fig. 22, *a*). The eggs are circular, not oval (Fig. 22, *b*), and, being discharged in the fæces while still within the segments, are set free, and gain access to the stomach of the pig or man. The segments commonly appear as chains in the fæces. The remainder of the life-history closely resembles that of the *T. mediocanellata*, substituting the pig or man for the ox, and the term *Cysticercus cellulosæ* (Fig. 23) for *C. bovis*. The cysticercus, besides occurring in the muscles, may be found in the human brain, eye, or subcutaneous tissue. It is rarely present in the lungs and heart.

Fig. 23.—*Cysticercus cellulosæ* from measly pork, × 24 diameters.

Geographical Distribution.—*T. solium* is common in North Germany. It occurs also in Southern Germany, France, Britain, and the United States. Its distribution corresponds to that of the domestic pig.

Method of Transmission. — Man is liable to obtain the parasite —(1) as cysticercus in measly pork; (2) as eggs in food or in water; (3) as eggs, by the introduction of soiled fingers into the mouth; (4) possibly by the ripe segments being passed into the stomach during the strain of vomiting.

Prevention of Origin and Spread.—Proper keeping of swine. Sanitary disposal of human excreta. Efficient cooking of pork. Cleanliness on the part of the host. The use of anthelmintics.

The other *Tæniadæ* occasionally met with in the human intestine are—

Name.	Intermediate Host.	Definitive Host in addition to Man.
T. nana (Fig. 24) . .	Probably insect or snail.	Rat.
T. cucumerina (Fig. 25) .	Dog and cat louse.	Dog and cat.
T. flavo-punctata . .	Unknown, probably an insect.	Rat.
T. madagascariensis .	Unknown.	Unknown.

Bothriocephalus latus (the Broad Pit-headed worm).—This hermaphrodite tapeworm passes its mature stage in the human intestine, and has

Fig. 24.—*Tænia nana*, × 10 diameters. (After Leuckart.)

for its intermediate host the pike, perch, turbot, sea-trout, and other fishes, which probably derive it from a mollusc forming their food. In addition to the ordinary symptoms, this parasite may cause profound anæmia. It measures from 20 to 60 ft. in length, and is to be recognised by the great breadth and relative shortness of its proglottides, and by their each possessing two central sexual openings (Fig. 26, *c*). The head is oval (Fig. 26, *a*); has two suctorial grooves, one on either side (Fig. 26, *b*), but does not possess a rostellum or hooklets. The eggs are oval in shape, each with a brown shell closed at one end by an operculum (Fig. 26, *d* and *e*). Released from the segments, which are expelled in lengths of from 2 to 4 ft., they are immature,

Fig. 25.—*Tænia cucumerina*, natural size. (After Leuckart.)

but after immersion in water for a varying time, according to temperature, they become fully developed into six-hooked ciliated embryos. Forcing back the opercula, they escape from their shells and swim about till they encounter the necessary mollusc, which they enter, and through it reach the fish. Their piscatorial pursuits being thus ended, they undergo changes, passing through a modified cysticercal stage, in which they lose their cilia and hooklets, elongate and develop their heads, tails, and suckers. At this stage they lie free, or are

Fig. 26.—*Bothriocephalus latus*. *a*, Head, flat surface, × 8 diameters. *b*, Head, edge, × 8 diameters. *c*, Segment. × 8 diameters. *d*, Egg, yolk cells, and shell, × 300 diameters. *e*, Egg, surface shell, × 300 diameters.

feebly encysted in the viscera or muscles, and, when the fish is eaten raw or insufficiently cooked or smoked, gain access to the human intestine.

Geographical Distribution.—It is endemic in Switzerland, Russia, and Japan, and, owing to exportation of fish, may appear in other countries.

Method of Transmission.—From the ingestion of raw or insufficiently cooked, cured, or smoked fish.

Prevention of Origin and Spread.—Condemnation of infected fish.

Efficient cooking or preservation of fish. Cleanliness on the part of the host. The use of anthelmintics.

Other *Bothriocephalada* found in the human intestine are—

Name.	Intermediate Host.	Definitive Host in addition to Man.
B. cordatus	Fish.	Dog.
B. cristatus	Unknown.	Unknown.

Tapeworms may cause no symptoms beyond the appearance of proglottides in the fæces. More often they produce capricious or inordinate appetite, gastro-intestinal irritation, reflex nervous symptoms, and sometimes, especially in the case of *Bothriocephalada*, anæmia.

NEMATODA.

Ascaris lumbricoides (Round worm).—This worm inhabits the upper part of the small intestine, but may migrate in various directions. It is not at all unlike the ordinary earth-worm, but it does not possess a clitellum. It is whitish grey or pink in colour, and the sexes are separate. The male worm is from 8 to 12 in. long: the females may be as much as 20 in. (Fig. 27, *a* and *b*). They taper towards each end, the cephalic extremity being the sharper. The long uterine tubes contain millions of ova, which vary in shape, and have rough pitted surfaces (Fig. 27, *c*). The latter are passed in the fæces, and under suitable warm and moist conditions the embryos develop in them as small coiled eel-like bodies, which cannot leave the eggs till these be swallowed by the definitive host, an intermediate host not being required, though possibly a stage may be passed in some worm or the larva of some insect. The embryos are slow in development, taking several months to come to maturity, and they remain alive inside the eggs for five years, as freezing in winter and excessive drying in summer merely inhibit growth without killing the young worms. On reaching a suitable host, such as man, ox, pig, and many other animals, the embryo leaves the egg and develops in a month into a sexually mature worm.

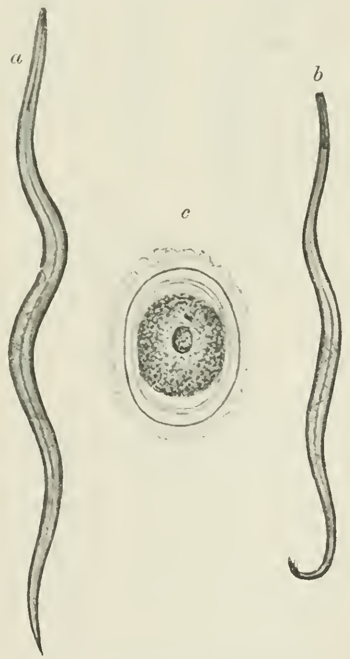


Fig. 27.—*Ascaris lumbricoides.* *a*, Female, half natural size. *b*, Male, half natural size. *c*, Egg, × 300 diameters.

Geographical Distribution.—World-wide, but the worm is more common in the tropics. It is also more frequent in the country than in towns. The worm is often multiple in the intestine, especially amongst those inhabiting warm climates, and is usually harmless, though it may cause discomfort and even serious complications.

Incidence.—Age.—Children are more commonly affected than adults.

Class.—Owing to their dirty habits, lunatics very frequently harbour round worms.

Method of Transmission.—Alimental, the eggs being taken in with drinking-water, fruit, or raw, uncleaned, or imperfectly cooked vegetables.

Prevention of Origin and Spread.—Care as to water supply, fruit, and preparation of green-stuffs for food. Personal cleanliness on the part of the host. Disinfection of all fæces containing ova. The use of anthelmintics.

Oxyuris vermicularis (*Syn.*, Thread-worm).—This worm inhabits the cæcum and rectum of man in enormous numbers. More rarely it is found in the dog. Its sexes are distinct, and the male worm is much smaller than the female, which varies in length from $\frac{1}{5}$ in. to $\frac{1}{2}$ in. The worms (Fig. 28, *a* and *b*) possess pointed heads, and resemble short, slightly motile pieces of white thread, and the male has usually a spirally coiled tail. The oval egg possesses a shell, which is thinner at one part of the dorsal surface than elsewhere, and it is at this point that the embryo escapes (Fig. 28, *c*). At the time the egg leaves the parent worm the embryo is not fully developed, and only becomes so when the eggs are in the fæces, either within or without the host (Fig. 28, *d*).

Fig. 28.—*Oxyuris vermicularis*. *a*, Female, with eggs, × 10 diameters. *b*, Male, × 10 diameters. *c*, Egg, freshly laid, × 300 diameters. *d*, Egg, with developed embryo, × 300 diameters.

No intermediate host is required, and, on the eggs being swallowed, the embryos are liberated in the stomach and pass to the small intestine, where they mature, and the females are impregnated. The males now die, but the impregnated females migrate to the cæcum, mature their eggs, descend to the rectum, and discharge their ova. The whole process may occupy from two to three weeks. The female worms, owing to their migratory powers, can leave the rectum and produce cutaneous irritation, necessitating scratching and a consequent fouling of the fingers, whereby the eggs may be conveyed to the mouth.

Geographical Distribution.—World-wide.

Symptoms.—Anal irritation, especially nocturnal.

Incidence.—Age.—Children are principally affected.

Method of Transmission.—Alimental, by water or food.

Fomital.

Direct corporeal as mentioned. Water is not such a frequent vehicle as in the case of the *Ascaris lumbricoides*.

Prevention of Origin and Spread.—Care as to water supply, food, etc. Cleanliness. Disinfection of stools containing ova. The use of anthelmintics. No one should share a bed with an affected person.

The following *Ascarides* also occur in the human intestine :—

Name.	Definitive Host.
A. mystax . . .	Dogs, cats, and some other carnivora.
A. maritima . . .	Unknown.

Ankylostomum duodenale (*Syn.*, Dochmius duodenalis, Tunnel worm).—This worm is found in the small intestine, and especially in the jejunum of man. Large numbers may be present at one time. It has been described in the dog and ape. The sexes are separate, and approach each other in size, the female being the larger. Their average length is about ½ in., and they are white in colour. The heads of both are furnished with four strong claw-like hooks, and two conical teeth. The female has a spinous tail, the male a caudal trilobate bursa like an umbrella (Fig. 29, *a* and *b*).

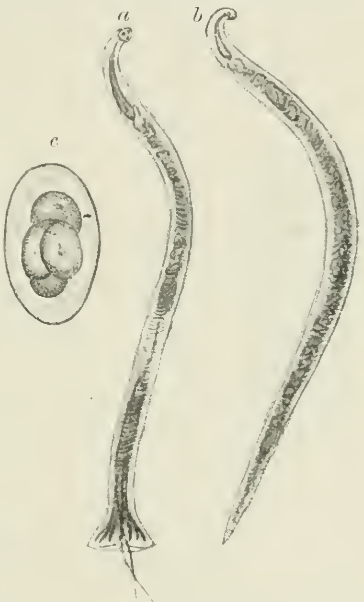


Fig. 29.—*Ankylostomum duodenale.* *a*, Male, × 8 diameters. *b*, Female, × 8 diameters. *c*, Ova, × 300 diameters.

The smooth oval egg contains a segmented yolk at the time when it leaves the female (Fig. 29, *c*). It passes out in the fæces, after which, under suitable conditions, development proceeds rapidly. An embryo is formed, which leads a free life, existing on organic matter, and growing for a week, during which time it moults twice. It then becomes more or less torpid, and, residing in mud or damp earth, pursues a sluggish existence for weeks or months, during which it may manage to reach its host. If it does so, entering the small intestine, it attains sexual maturity in about a month.

Geographical Distribution.—It is endemic in many hot countries, such as Egypt, India, Brazil, the West Indies, and Japan. It is rare in Britain. In Europe it is specially remembered in connection with the anæmia from which the workmen employed on the St. Gothard tunnel suffered, hence its soubriquet of "tunnel worm."

Symptoms.—It causes the disease known as Ankylostomiasis, characterised by cachexia and extreme anæmia, due to the extraction of blood from the intestinal walls. Intestinal catarrh, fatty degeneration, and effusions leading to death are other sequelæ.

Incidence.—Agriculturists, brickmakers, and miners are specially liable to the disease.

Differential Diagnosis.—Distinguish from beri-beri and malaria.

Method of Transmission.—*Alimental.*—*Direct corporeal,* as in re-infection. The recent experiments of Looss show that the larvæ can penetrate the unbroken skin, provided they are in contact with it for a sufficiently long time. They gain access chiefly by the hair follicles, and thus reach the subcutaneous tissues.

Prevention of Origin and Spread.—A pure water supply. Boiling and filtering of all doubtful drinking-water. The use of anthelmintics. Disinfection of stools. General cleanliness, combined with proper conservancy methods, or, failing these, the sanitary regulation of latrines to prevent the mixing of undisinfected fæces and earth. Inspection of native labourers. The distribution of notices giving information regarding the disease and the methods to be employed for its prevention and cure. Infected soil should be abandoned, or treated by ploughing, firing, or disinfection.

Trichocephalus dispar (Trichocephalus hominis or Whip-worm).—This nematode worm inhabits the human cæcum. The sexes are distinct, and each has a long, thread-like neck. The female is longer than the male, the average length being from $1\frac{1}{2}$ to 2 in. The body of the female is straight, that of the male being coiled, and ending in a cloaca with a spike (Fig. 30, *a* and *b*). The oval eggs are brown, spindle-shaped, and have a clear pole at either end (Fig. 30, *c*). The embryo develops in water, and is set free after the egg is swallowed by man. In five or six weeks' time it has become sexually mature.

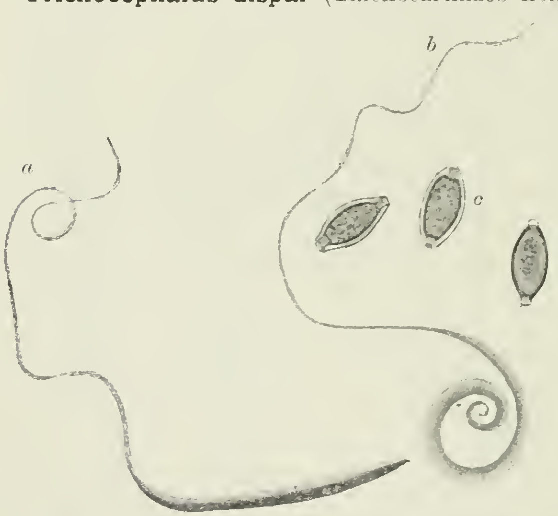


Fig. 30.—*Trichocephalus dispar.* *a*, Female, × 5 diameters. *b*, Male, × 5 diameters. *c*, Ova, × 200 diameters.

Geographical Distribution.—World-wide, but is more common in the tropics.

Method of Transmission.—*Alimental,* in drinking-water.

Prevention of Origin and Spread.—A pure water supply. The boiling or filtering of any doubtful drinking-water. Cleanliness. Disinfection of stools. The action of anthelmintics is ineffective, but fortunately the worm is harmless.

Trichina spiralis.—The worm in its mature form is found in man, in whom it also occurs during its encysted stage. Numerous animals may serve as hosts, but trichinæ do not breed in cold-blooded animals. The rat and the pig are its most frequent entertainers, in whom it also occurs in both its forms, the mature form in the intestines, the encysted in the muscles. The worm may spread from rat to rat, owing to the cannibal habits of the rodent, and from rat to pig, owing to the latter's indiscriminate feeding. Man obtains the parasite from the pig, by the ingestion of insufficiently cooked pork containing the encysted form, the so-called "measle" of pork. Reaching the stomach, the cysts are dissolved by the gastric juices, and the parasites are set free. These pass into the small intestine, rapidly complete their sexual development, and the female becomes impregnated. At this stage the parasites are small worms (Fig. 31, *a* and *b*) about $\frac{1}{10}$ in. long, with finely pointed heads, the male being provided with a pincer-like appendage at the caudal end, which is furnished with a cloaca. The vulva of the female is in the anterior part of the body, and from it, the ova being ovo-viviparous, the eggs or young trichinæ escape. The male dies after effecting impregnation. Following this act the female grows rapidly to two or three times her original size, and begins to discharge her eggs or young trichinæ six or seven days after reaching her host. She continues to do so for five or six weeks, and then dies and is voided. The young trichinæ are minute kite-shaped organisms, with tapering tails (Fig. 31, *c*). They migrate through the walls of the intestine till they reach voluntary muscle, or certain other tissues, where they become provided with a capsule, and lie in the connective tissue spaces (Fig. 31, *d*). This process takes ten days. Encysted in the muscle, the parasite remains motionless, and coils up into a spiral, having a thick anal and a thin oral end. It possesses an alimentary canal, and the sexes are distinct. No change may take place for many years, or death and calcification may supervene. This stage in man corresponds to the measle of pork with which our description of the parasite commenced. The vitality of the encysted trichinæ can be demonstrated by the fact that they do not stain with anilin-blue as do the dead organisms. They lie in the long axis of the muscle, and the capsule contains a clear albuminous fluid. It will be apparent that the worm has now no further chance of development, unless the human flesh be devoured.

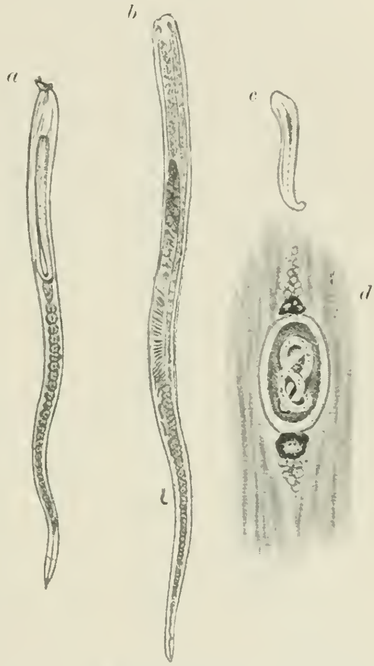


FIG. 31.—*a*, Mature trichinæ, male, magnified. *b*, Mature trichinæ, female, magnified. *c*, Embryo, magnified. *d*, Encysted *Trichina spiralis* in muscle, × 35 diameters.

Geographical Distribution.—World-wide, and influenced by human habits of life and the feeding of pigs. It is common in Germany, Holland, Denmark, and America.

Symptoms.—The worm produces the disease called Trichinosis, the symptoms of which vary with the stage of development of the parasite :—(1) Intestinal irritation, corresponding to the breeding and migration stages. This may be entirely absent ; (2) muscle inflammation, corresponding to the stage of muscle invasion ; (3) diminishing myositis, corresponding to the completely encysted stage. The symptoms may be so intense that death may ensue, usually in the second stage, from asphyxia, the diaphragm and intercostal muscles being specially affected. Various complications may also bring about a fatal issue during any of the three stages.

Differential Diagnosis.—Distinguish from enteric fever, rheumatism, cholera, and beri-beri.

Mortality.—It varies greatly in different epidemics.

Method of Transmission. — *Alimental.*—In the case of the lower animals, it is conceivable that adult living worms expelled in the fæces might gain admission to the alimentary canal.

Prevention of Origin and Spread.—Systematic microscopic inspection of swine flesh intended for human food. France interdicts the importation of American pork. Such a restriction is not required in Britain. Thorough cooking of pork and ham, the internal portions of the meat being raised to a sufficiently high temperature, about 153° F. It must be noted that the encysted trichina is very resistant to high and low temperatures, putrefaction, drying, and pickling, so that smoked and pickled hams and pork require inspection as well as the fresh meat.

Further, trichinosis may be transmitted by the ingestion of lard, sausage skins, and sausages themselves, as the cysts are not confined to the muscle, but occur in the panniculus adiposus, the coats of the intestine, and the scraps so frequently used in pork factories for the manufacture of sausages.

Attention must therefore be directed to these sources of infection.

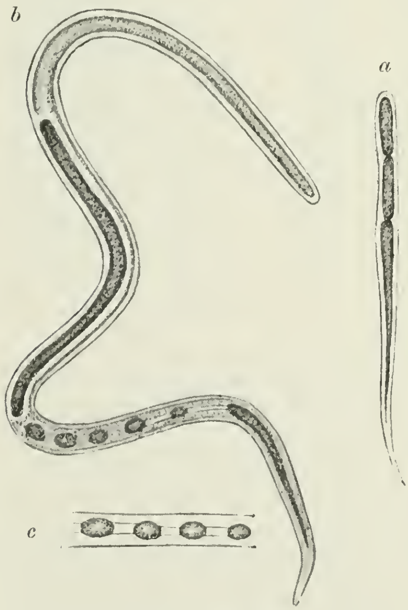


Fig. 32.—*Rhabdonema intestinale.* *a*, Male. *b*, Female. *c*, Ova.

Rhabdonema intestinale.—This worm infests the duodenum and jejunum of man, but is harmless. In the parasitic form the adult female alone is known. The worm has also been demonstrated in fowls.

It is a thin parasite, $\frac{1}{15}$ to $\frac{1}{10}$ in. in length, and may be recognised by the accumulation of five or six eggs about the centre of its body (Fig. 32, *b*). The ova pass into the intestinal contents, and the contained embryos rapidly develop, the shells are ruptured, and the young parasites dart hither and thither amongst the fæces (Fig. 32, *a*). The ova themselves are thus rarely found in the fæces, but when present occur in short strings (Fig. 32, *c*). The embryos are voided with the fæces, and if they are to live the fæces must reach water. For the development of sexual forms with the sexes distinct, a high temperature is necessary. Thus the free adult forms are produced, which form embryos, and these embryos being transferred to man become the adult parasitic forms. At a low temperature the original embryo develops into a filariform larva, which likewise becomes parasitic if it gains access to man.

Geographical Distribution.—Cochin-China, Egypt, Brazil, etc.

Method of Transmission.—*Alimental.*—Water is the chief vehicle.

Possibly *aerial*, in wind-borne dust.

Prevention of Origin and Spread.—Pure water supply. Proper cooking of vegetables. The use of anthelmintics.

Strongylus subtilis.—

Geographical Distribution.—Egypt.

It is found in the small intestine, and produces no symptoms.

The following *Trematodes* are found in the human intestine:—

Name.	Definitive Host.
Distoma heterophyes . .	Man. — It has been found in two instances in Cairo.
Amphistomum hominis .	Man.—It has been found in Assam.

INSECTA.

The larvæ of dipterous insects may be found in the stools, chiefly in tropical regions, the ova having been swallowed.

II. HÆMOPOIETIC SYSTEM.

CESTODA.

Splenic hydatid, due to the *Tænia echinococcus*, may occur. It has to be distinguished from cyst in the left hepatic lobe, waxy spleen, chronic splenic congestion, and splenic abscess.

NEMATODA, FILARIDA.

Filaria sanguinis hominis.—This term is common to four, if not five, species of embryonic filaria. The embryonic filariæ are long, slender worms, with a wriggling, serpentine movement, and are found in the blood of man.

Thus the *F. diurna* is present in the blood by day only.

Thus the *F. nocturna* is found in the blood by night only.

Thus the *F. perstans* and *demarquaii* are constantly present in the blood both by day and night.

The fifth is the *F. magalhæsi*, about which very little is known, as it has only once been found, and then in the blood post-mortem.

General Description of these Filariæ.—The adult forms, where known, are bisexual, long white thread-like worms, the female somewhat larger than the male, the average length being about 3 or 4 in. They occur in the lymphatics and other tissues. The females produce eggs, which develop into embryos that migrate into the blood stream. From the blood they pass into an intermediate host, such as a mosquito, and in it they perforate the intestinal wall, and, having reached a nidus in the body of the insect, they there undergo certain changes, and at the death of the mosquito are set free in water. With the water they are absorbed by man, and bore their way through his tissues till they reach the lymphatics, where they develop into the adult forms already described.

Thus the adult forms of the *F. nocturna* are known to be the *F. bancrofti*, which live in the lymphatics of the trunk and extremities, and look like living white hairs (Fig. 33, *a*). They are 3 to 4 in. in length, and have tapering heads and tails. The ova while yet inside the female develop into embryos, which are set free in the lymph, and, following the lymphatics, reach the blood, where they are found as the *F. nocturna*, free and motile.

FIG. 33.—*a*, Parental form. *Filaria bancrofti*, female (natural size). *b*, Embryonic form. *F. nocturna*, × 300 diameters.

They are about $\frac{1}{50}$ in. in length, with sharp tails, and possess a boring and cephalic armature, consisting of a proboscis armed with a spine and covered by a hood which can be retracted or protruded. The whole embryo is enclosed in a delicate sheath composed of the remains of the membrane which formerly lined the egg (Fig. 33, *b*). This sheath is for the purpose of rendering the armature ineffective, so confining the embryo to the blood vessels, and thus ensuring its meeting with its intermediate host the mosquito. The insect, as is well known, only bites between sunset and sunrise, which explains the nocturnal presence of the embryo in the blood stream. The mosquito takes up the embryo along with the blood, and in the stomach of the insect the sheath is fixed by the viscid blood, and is penetrated by the little embryo, whose cephalic armature now comes into play for the first time. Once free of the sheath, the embryo loses no time in boring through the stomach wall of the mosquito and taking up a lodgment in the thoracic viscera, where it remains in a passive state till the death of the insect. In all probability it thus reaches water, and, being imbibed by man, makes its way to the lymphatics, where it is found as the *F. bancrofti*, its adult form.

Geographical Distribution of the F. nocturna.—It is practically confined to tropical and subtropical regions.

Symptoms.—It causes a varicose condition of the lymphatics, which are liable to become inflamed or blocked, and thus to give rise to the symptoms of chyluria, chylocele, varicose groin glands, lymph scrotum, etc. Elephantiasis arabum is probably also due to this parasite.

Method of Transmission.—*Alimental*, being water-borne.

Prevention of Origin and Spread.—A good water supply. Filtering or boiling of suspected water. Protection of drinking-water from mosquitoes. Filarious individuals should sleep under mosquito netting, and at a distance from the water supply or water stored for drinking purposes.

The *F. diurna* probably has the *F. loa* as its adult form. It appears in the blood at 8 a.m., increasing in numbers till midday, and entirely vanishing at 9 p.m. Its intermediate host is unknown. It may possibly be the mangrove fly.

Geographical Distribution.—The West Coast of Africa within the tropical belt.

Symptoms.—Nil.

The *F. perstans* is now, thanks to Manson, known both in the free embryonic and adult forms. The former is sparingly present in the blood both day and night, possesses a spine at the cephalic end, a truncated caudal end, but no sheath, and is capable of free movement through the blood stream. The latter is identical with that parental form of the *F. ozzardi* which produces blunt-tailed embryos.

Geographical Distribution.—The West Coast of Africa within the tropical belt.

Symptoms.—It has been suggested that this parasite may be the cause of a strange disease known as—

The **sleeping sickness** or **negro lethargy**, which, in any case, it will be convenient to consider in this place.

Geographical Distribution.—It is endemic in the West Coast of Africa, roughly speaking, between the Senegal and Congo basins, but unequally distributed over this area. It is liable to become epidemic, and may occur in persons who have been long absent from the endemic area, even if they be resident in temperate climates. The disease is unknown amongst persons who have not lived in its habitat.

Description. — The *incubation period* is uncertain, but may be very prolonged.

Symptoms.—The onset is insidious, and the disease is characterised by a gradually increasing torpor of the mental and physical functions, irregular fever, staggering gait, muscular weakness, and a tendency to sleep at all times, ushering in the final stage of wasting, bed-sores, tremors, and convulsions, terminating in coma and death. Recovery is very rare, and the disease runs a course of from four months to four years.

Differential Diagnosis.—Distinguish from beri-beri, general paralysis of the insane, and myxœdema.

Mortality.—It is very high, though the disease may apparently abort.

Incidence.—*Age* exercises no influence, nor does *sex*.

Race.—Negroes are chiefly liable, but the disease is not confined to them.

Method of Transmission.—Unknown. If due to *F. perstans*, probably by means of drinking-water.

Prevention of Origin and Spread.—A pure water supply. Otherwise unsatisfactory, owing to doubtful etiology.

F. lymphatica, *F. volvulus*, *F. restiformis*, and *F. inermis* are very rare in man. They are parasitic in the lower animals.

F. demarquaii is a small filaria found in the blood of West Indian natives, and present both by day and night. It may be the embryonic form of the next variety.

F. magelhæsi.—Has been once found post-mortem in South America.

F. ozzardi is a name common to two South American varieties of embryo, one of which, in its parental form, is identical with the parental form of *F. perstans.*

TREMATODA.

Bilharzia hæmatobia is a distomum, but is not hermaphrodite. The male is about $\frac{2}{3}$ in. long, and is a white worm really flat in shape, but having its edges infolded so as to partially enclose the female in the groove so formed (Fig. 34). The female is of darker hue, about $\frac{4}{5}$ in. long, thread-like, and is thinner than the male worm, which encloses her in his canal, with the exception of her head and tail ends. These parasites are found in the blood of the larger veins, especially in the portal system, and the female, passing from these to small veins in the rectal and bladder walls, there deposits her eggs. The oval eggs, which have translucent capsules and are furnished with one spine apiece, penetrate the rectal or bladder wall, causing effusion of blood, and are voided in the fæces or urine (Fig. 35, *a* and *b*). Each contains a ciliated embryo (Fig. 35, *c*) which escapes from the egg (Fig. 35, *d*), and if it gains access to fresh water is capable of development, swimming about freely in the medium. Its further history is unknown, but it probably enters some intermediate host, such as a mollusc, where it undergoes further changes, and eventually gains access to man, in whom, and in some of the higher apes, it is alone found.

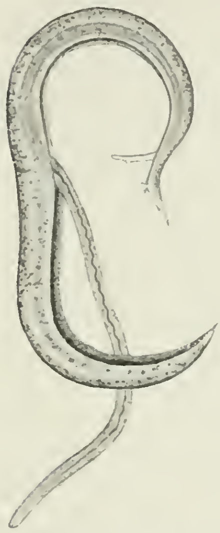


Fig. 34.—*Bilharzia hæmatobia*, male and female. (After Leuckart.)

Geographical Distribution.—Africa, Arabia, India. It is very frequently encountered in Egypt, and is common in Northern Natal.

Symptoms. — It produces hæmaturia and, at times, symptoms of dysentery. The irritation of the urinary tract may be so severe as to prove fatal from nephritis, cystitis, calculus, or neoplasm.

In examining the urine for ova, the last drops passed with straining should be collected and subjected to microscopical examination under a low power.

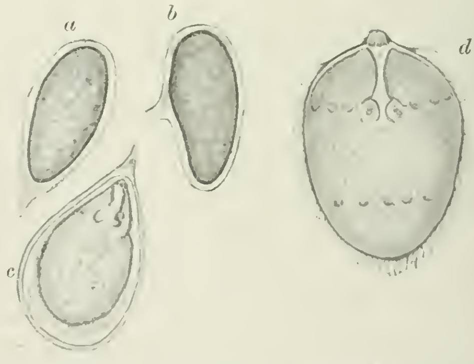


Fig. 35.—*a*, Immature ova of *B. hæmatobia*, with terminal spine; *b*, Immature ova, with lateral spine; *c*, Mature ova, × 200 diameters. *d*, Free embryo, × 300 diameters.

Endemic hæmaturia, as the disease is called, may last for months or years, and is rarely cured.

Differential Diagnosis.—Distinguish from nephritis, cystitis, calculus, neoplasm, prostatic disease, eustrongylus gigas, and dysentery.

Incidence.—It is more common in males.

Method of Transmission.—*Alimental*, by drinking-water in all probability, though the ingestion of infected molluscs with raw vegetables or of fish may be a means of conveyance. It has been stated that the ova can gain admission to the human body through the skin or viâ the urethra.

Fig. 36.—*Aspergillus niger*, × 100 diameters.

Prevention of Origin and Spread.—A pure water supply, if possible, must be obtained. Boiling and filtering of suspected water is necessary.

The prevention of fouling of water supplies by infected stools or urine is essential.

III. RESPIRATORY SYSTEM.

Aspergillus niger, one of the hyphomycetes or moulds, has been found saprophytically in man, affecting the lungs and giving rise to symptoms somewhat resembling those of actinomycosis. It appears as a mass of felted and pigmented filaments, and possesses gonidia and spores (Fig. 36).

TREMATODA.

Distomum ringeri.—This is a small oval, thick, reddish brown fluke, about $\frac{1}{3}$ in. long and $\frac{1}{4}$ in. broad (Fig. 37, *a*). The eggs are dark brown, smooth, oval, thick-shelled, and operculated, and are found in the sputum (Fig. 37, *b*). From the sputum they reach water, undergo the developmental changes common to the distomidæ, and again reach man, either in water or through some intermediate host.

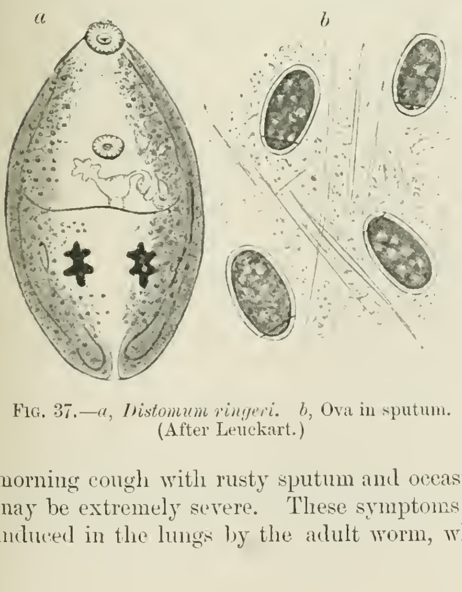


Fig. 37.—*a*, *Distomum ringeri*. *b*, Ova in sputum. (After Leuckart.)

Geographical Distribution.—China, Japan, and the United States.

Symptoms.—It causes the disease known as Endemic hæmoptysis, which is common in Japan, Corea, and Formosa, and is characterised by chronic morning cough with rusty sputum and occasional attacks of hæmoptysis, which may be extremely severe. These symptoms are due to the pathological changes induced in the lungs by the adult worm, which forms so-called "burrows" or areas of disintegrating infiltration which contain the rusty sputum and the distomes.

Differential Diagnosis.—Distinguish from phthisis, bronchiectasis, and pulmonary neoplasm.

Method of Transmission.—*Alimental.*

Prevention of Origin and Spread consists in obtaining a pure water supply, and the avoidance of uncooked vegetables. The collection and disinfection of infected sputa.

CESTODA.

Hydatids due to *T. echinococcus* may affect the lungs, and have to be distinguished from phthisis, pleural effusion, and liver hydatid.

NEMATODA.

Strongylus longivaginatus has once been found in the human lungs. It is like the strongylus common in the air passages of the lower animals.

INSECTA.

Lucilia hominivora, or **Macellaria** (Screw-worm).—This fly, closely resembling the common blue-bottle, may deposit its eggs in the anterior nares, and the larvæ being there hatched produce extensive destruction while developing. Septicæmia, meningitis, or hæmorrhage may result, and a fatal issue is not uncommon. This fly is found in Central and South America. And similar symptoms may be produced by the larvæ of the *Sarcophaga carnaria*, which exists in Russia and Central Europe.

Prevention of Origin and Spread is aided by the avoidance of sleeping in the open air unprotected by netting.

ARACHNIDA.

Pentastomum denticulatum and **P. constrictum** may occur in the lungs. (See p. 80.)

SUCTORIA.

Small leeches may gain a lodgment in the posterior nares and air passages, and cause headache, cough, nausea, epistaxis, spitting of blood, and even anæmia.

IV. URINARY SYSTEM.

Infusoria may occur, but are apparently of no importance.

TREMATODA.

Bilharzia hæmatobia (see p. 94).

CESTODA.

Hydatid of kidney (see p. 79). It has to be distinguished from hydronephrosis, cystic kidney, ovarian and parovarian cysts, phantom tumour, and nephritic abscess.

NEMATODA.

Eustrongylus gigas.—This large nematode worm is found in the pelvis of the human kidney, and is known to affect the dog and certain of the fish-eating lower animals. It resembles a round worm, but is of greater length, and the male has a large copulatory bursa at its caudal extremity. The female is longer than the male. The ova are oval, and have thick brown pitted shells. They contain fully or partly developed embryos when laid. These eggs are voided in the urine and pass to water, where the embryos are set free and develop. It is probable that a fish forms the intermediate host, but nothing definite is known.

Geographical Distribution.—It is widespread over Europe and North and South America.

Symptoms.—They resemble those of calculus and endemic hæmaturia.

Differential Diagnosis. — Distinguish from *Bilharzia hæmatobia*, nephritis, cystitis, calculus, neoplasm, and prostatic disease.

V. NERVOUS SYSTEM.

CESTODA.

Hydatid of the Brain (see p. 79).

It has to be distinguished from brain neoplasm, tubercular meningitis, and hydrocephalus.

Tænia acanthotrias has once been met with in the human body, affecting the brain, muscles, and skin, and is only known in the cysticercal stage.

NEMATODA.

Filaria oculi humani may occur in the crystalline lens, or in the anterior or posterior chambers of the eye. Its life-history is unknown.

TREMATODA.

Distomum ophthalmobium has been once found in the crystalline lens of the human eye. Its life-history is unknown.

D. ringeri may affect the brain, forming a "cerebral burrow," and giving rise to an anomalous and fatal form of Jacksonian epilepsy.

VI. LOCOMOTORY SYSTEM.

Miescher's tubes have been described in human muscle, but are chiefly observed in the lower animals.

CESTODA.

Tænia acanthotrias (see above). **Trichina spiralis** (see p. 88).

VII. SEROUS CAVITIES.

CESTODA.

Bothriocephalus mansonii is a larval form found in the peritoneal and pleural cavities, and probably elsewhere. Its definitive host may be one of the carnivora associated with man.

The Hydatids of **T. echinococcus** may affect serous cavities.

VIII. CONNECTIVE TISSUE.

NEMATODA.

Filaria loa.—A parasite found in the subcutaneous areolar tissue, common in the eyelids and under the conjunctiva. It is like a thick white thread, and is about 1 in. in length. It is bisexual, ovo-viviparous, and may possibly be the mature, parental form of *F. diurna.*

Geographical Distribution.—The West Coast of Africa, chiefly Old Calabar.

Symptoms.—As it moves about freely it may give rise to mechanical irritations, and may be seen travelling beneath the conjunctiva or thin parts of the skin.

Filaria medinensis (*Syn.*, Dracunculus medinensis, or Guinea-worm).—The female worm alone is known. Its average length is 2½ ft. (Fig. 38, *a*). It has a white cylindrical body and a uterus filled with embryos. Six papillæ surround the triangular-shaped mouth, and the rounded head is furnished with a cephalic shield. It is found in the subcutaneous tissues of the lower limbs, rarely elsewhere, and moves about in the connective tissue of the legs or trunk. Manson graphically describes the "nesting" of the worm as follows: "When the parent dracunculus approaches maturity, she begins to move slowly through the tissues, head first, and in 90 per cent. of cases in a downward direction until her head arrives at the foot, ankle, or leg. The head then drills a small hole in the derma, sparing the epidermis; over this hole a bulla forms; . . . in the course of a few days the bulla ruptures, disclosing a small superficial ulcer with the afore-mentioned minute hole in its centre. Sometimes on rupture of the bulla . . . the head of the worm is seen protruding from the little hole."

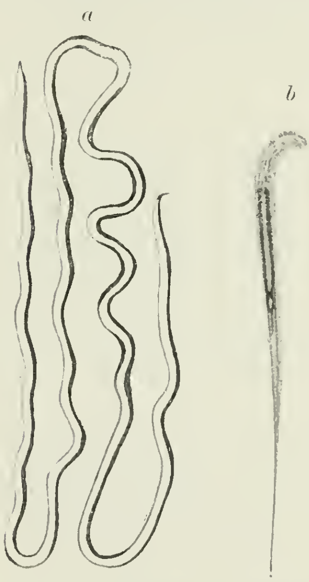


Fig. 38.—*a*, *Filaria medinensis*, guinea-worm, reduced. *b*, Embryo of guinea-worm, × 100 diameters. (In part after Leuckart.)

Cold water poured on the ulcer causes a whitish fluid to well out, or sometimes a small tube is protruded. The former is the contents of the ruptured uterus, the latter the uterus itself prolapsed through the mouth of the worm. The tube bursts, and its contents are spilled over the ulcer surface, the whitish fluid containing a mass of wriggling embryos. After this discharge, lasting about a fortnight, the worm is ready to quit the host, either spontaneously or as the result of gentle traction.

The embryos (Fig. 38, *b*) naturally reach the cyclops quadricornis through the medium of water, especially if it be muddy. This crustacean constitutes its intermediate host. The further history is unknown.

Geographical Distribution.—West Coast of Africa, Persia, parts of India and Turkestan, portions of Brazil.

Symptoms.—The horse, dog, or ox may be affected by the ulceration which the worm produces. There is abscess formation if the worm dies or fails to pierce the skin.

Method of Transmission. — *Alimental*, by drinking-water. It is supposed that the cyclops is ingested with the water.

Prevention of Origin and Spread.—A pure water supply is essential. Destruction of the worm by antiseptic injections.

IX. REPRODUCTIVE SYSTEM.

INFUSORIA.

Trichomonas vaginalis, a form of flagellated infusorian occurring in the acid mucus of the human vagina. They are of importance from a medical jurisprudence standpoint, owing to their resemblance to human spermatozoa.

X. INTEGUMENTARY SYSTEM.

HYPHOMYCETES.

Aspergillus niger sometimes occurs in the skin of the external auditory meatus, producing otomycosis.

Achorion Schönleinii is the parasite producing the disease known as Favus. It is an oidium resembling *Oidium lactis.*

Symptoms.—Favus affects the skin of the scalp and other parts as well as the hair and nails. Yellow cup-shaped crusts result, having a characteristic mouse odour. Cats, rabbits, and mice are affected. Baldness frequently follows favus of the scalp.

Geographical Distribution.—It is rare in England; common in Scotland, Germany, and France.

Incidence.—*Age.*—Children, especially the ill-nourished, harbour this parasite.

Method of Transmission.—*Direct corporeal.*—It is possible that the cat may be infected from the mouse, and the child from the cat.

Prevention of Origin and Spread.—Cleanliness; partial isolation with regard to school attendance; epilation.

Microsporon furfur produces the skin affection known as Pityriasis versicolor. It is a form of fungus affecting the skin of the chest, abdomen, and sometimes the back. The disease presents itself as brown branny patches, the fungus growing only on the superficial layers of the epidermis, and microscopically showing spores and mycelium.

Incidence.—*Age.*—It is rare in children and after middle life.

Method of Transmission.—*Direct corporeal.*

Prevention of Origin and Spread.—Cleanliness and antiseptic applications.

Trichophyton tonsurans was the name applied to the fungi producing ringworm. Some grow in, some on, the hair, destroy it, and produce circular or oval bald patches. Ringworm of the body is known as *Tinea circinata, marginata,* and *imbricata.* All ringworms tend to die out at the centre, and spread at the margins. Spores and mycelium are found microscopically, and three separate forms of vegetable parasite have been described, namely, *Microsporon audouini*, the cause of nearly all scalp ringworms, and never found in the beard or nails; *Trichophyton megalosporon endothrix*, which is the cause of *Tinea circinata*; *Trichophyton megalosporon ectothrix*, which is the cause of beard and nail ringworm.

Incidence.—It is greatest on the young between the ages of 3 to 4 and 9 to 10.

Method of Transmission.—*Direct corporeal.*

Prevention of Origin and Spread is secured by cleanliness, especially as regards toilet requisites. Partial isolation, especially as regards school attendance; a fortnight should elapse after apparent cure before return to school. Antiseptic applications.

VERMES, NEMATODA.

Rhabditis niellyi is a nematode worm found in the vesicle of a papulo-vesicular eruption of which it is supposed to be the cause.

Filaria medinensis (see p. 98).

Pinta and piedra are epiphytic diseases of the skin and hair, confined to tropical countries.

INSECTA.

Cuterebra noxialis.—This is a fly found in Central America, which frequents the outskirts of woods, and lays its eggs on man, cattle, and dogs, its larvæ being known as the *Macaco worm*. They penetrate the skin, causing much irritation.

Ochromyia anthropophaga.—This insect, found in Senegambia, lays its eggs in the sand, and the larvæ bore through the human cutis, and give rise to inflammatory indurations.

Gnats and mosquitoes.—The males are harmless; the females alone bite, and may produce great irritation and even malaise. The association of mosquitoes with malaria, yellow fever, and filariasis is discussed elsewhere.

Pulex penetrans (Jigger, chigoe, or sand flea).—

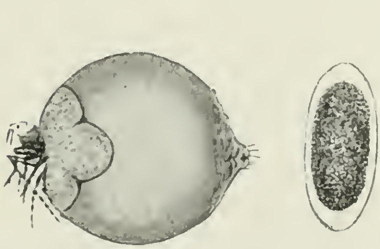


Fig. 39.—*Pulex penetrans* (chigoe), female, × 15 diameters. Egg, × 50 diameters.

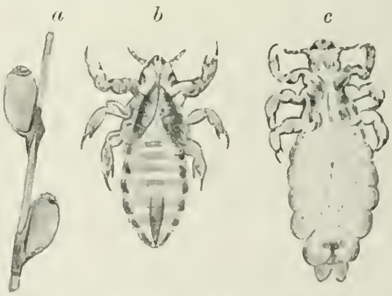


Fig. 40.—*Pediculus capitis.* *a*, Hair, with eggs; *b*, Male; *c*, Female, × 12 diameters.

Geographical Distribution.—West Indies, South America, and some parts of Africa and China.

Both sexes live in the blood, but the male is relatively harmless. The adult female (Fig. 39), however, penetrates the skin, usually that of the feet, beneath which she produces her eggs, and causes much pain and inflammation and, it may be, an open sore. Dry sandy soils and the floors of dirty huts constitute the habitat of this justly dreaded pest, which attacks all warm-blooded animals.

Prevention of Origin and Spread.—The feet should be protected. Cleanliness of houses, byres, poultry runs, etc., is essential. Insecticides should be used.

Pediculus (Louse).—There are three chief species, affecting respectively the heads, clothes, and pubic hairs of mankind. These are sufficiently differentiated in the accompanying illustrations (Figs. 40, 41, 42).

Fig. 41.—*P. vestimentorum*, female, × 12 diameters.

Fig. 42.—*P. pubis*, × 12 diameters.

P. capitis and **P. pubis** attach their operculated eggs to the body hairs, while **P. vestimentorum** lays its ova in the clothing, especially in the parts in contact with moist and warm spots.

Method of Transmission.—Direct corporeal, fomital.

Prevention of Origin and Spread.—Cleanliness, shaving the hairy

a *b*

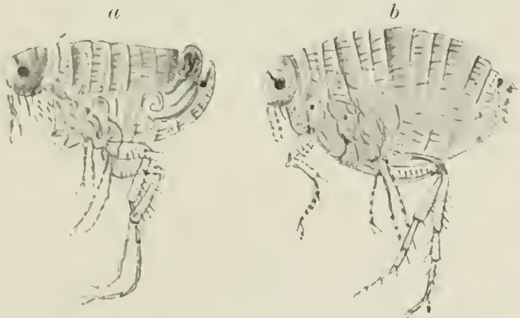


Fig. 43.—*Pulex irritans*. *a*, Male; *b*. Female, × 12 diameters.

parts when affected. The use of paraffin oil and antiseptics, disinfection of fomites.

Pulex irritans (Common flea) (Fig. 43).—It produces the condition known as *Phtheiriasis*.

ARACHNIDA.

Acarus scabiei (Sarcoptes hominis, or Itch insect) (Fig. 44).—The accompanying illustration sufficiently pictures the grey-coloured semi-transparent parasite, the female of which alone is hurtful, forming burrows in the skin wherein to lay her eggs, and thus setting up irritation, which is further increased by the piercing movement of the larvæ. Externally the burrows appear as white, slightly-raised tunnel roofs. The hands, especially the parts between the fingers, the buttocks, and the thighs, are the portions of the body principally affected, and the itching is often intolerable.

Method of Transmission.—*Direct corporeal; fomital*, as from beds, clothes, etc.

Prevention of Origin and Spread.—Cleanliness; use of antiseptics; disinfection of fomites.

Japanese River Fever may possibly be due to a variety of acarus. It is an acute endemic disease.

Geographical Distribution.—It is endemic in tracts of country used for hemp cultivation, and situated near two Japanese rivers.

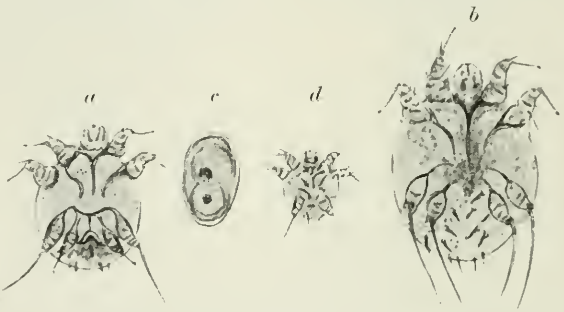


Fig. 44.—*Acarus scabiei*. *a*, Male; *b*, Female; *c*, Ova; *d*, Young embryo, × 80 diameters.

Symptoms.—The *incubation period* varies from four to seven days.

It begins with headache and general febrile manifestations, and is characterised by the presence on the skin of the genitals or armpits of a small circular, tough adherent slough associated with lymphatic inflammation, and eventually becoming an ulcer.

A rash appears on the sixth or seventh day of the fever, and serious complications may ensue.

Mortality.—15 per cent.

Incidence.—The disease is wholly confined to those engaged in the hemp industry in the regions above mentioned, and men, women, and children are alike susceptible. The fever occurs at the time of the hemp harvest, namely, July and August.

Immunity.—One attack does not protect, though it mitigates the severity of subsequent invasions.

Method of Transmission.—There is no direct transmission from the sick to the healthy. Hemp may be the medium of conveyance, but as the precise cause is as yet unknown nothing further can be said on this subject.

Prevention of Origin and Spread is obtained by protection and cleanliness of the skin.

Demodex folliculorum is a form of acarus frequently found in the sebaceous sacs and hair follicles of the human subject, thus occurring in the so-called "black heads" or comedones, which frequently precede or are coincident with acne eruptions. The parasite itself, however, is harmless, and its appearance is shown in Fig. 45.

Ixodes or *ticks* may occasionally infest man, being derived from the lower animals, such as horses, sheep, pigeons, etc.

Fig. 45.—*Demodex folliculorum*, × 80 diameters.

SUCTORIA.

Hæmadipsia ceylonica.—This is a small variety of active land leech, which extracts blood through the skin, and whose persistent attacks have been known to prove fatal.

III. OCCUPATIONAL DISEASES.

Under this heading it is proposed to deal only with those diseases of occupation which have a direct bearing on the Public Health, or come within the scope of Sanitary Science.

Plumbism.

Syn., Saturnism, Chronic Lead Poisoning.

Incidence as to Trades.—It affects ore smelters, red and white lead workers, potters, enamel-plate makers, file makers, glass-cutters, type-founders, type-setters, weavers, calico-printers, wall-paper makers, and those engaged in the "satining" of white paper and the manufacture of velvet paper. Also house painters, leather varnishers, artificial flower and jewel makers, silk and alpaca dyers, lace and straw hat preparers, sheet lead rollers and leaden pipe makers, dressmakers and tailors, wood and garnet polishers, makers of linoleum, and dippers of venetian blinds.

It is to be noted that lead miners rarely suffer from plumbism.

Incidence as to Individuals.—Young women are specially liable.

Mode of Access.—Lead gains access to the system by the alimentary, respiratory, and integumentary systems, the most dangerous and rapidly induced forms of plumbism resulting when the absorption is through the respiratory channels.

Symptoms.—Lead affects the alimentary system, causing the well-known blue line on the gums, colic, and constipation; the nervous system exciting the so-called encephalopathy, namely, headache and epileptiform convulsions, with musculo-spiral paralysis, amblyopia, and, it may be, peripheral neuritis; the circulatory system inducing gout, arterial sclerosis, and a tendency to cerebral hæmorrhage; the urinary system leading to albuminuria and cirrhosis; the hæmopoietic system resulting in anæmia; the reproductive system impelling abortion; and the locomotory system producing arthralgia and gout.

Short of death, plumbism is the cause of chronic cachexia, melancholia, blindness, mental infirmity, and muscular weakness.

Prevention.—In the case of lead, as in that of all poisonous metals employed in trades, certain general rules apply which may be conveniently tabulated as follows:—

Precautions.—(A) *As regards the community*.—(1) No effluent or waste should be admitted into streams, wells, ponds, or sewers, or distributed indiscriminately over any piece of land where it may gain access to the ground water or to water supplies. (2) Fumes discharged from chimneys must not be in such a noxious condition as to affect people, vegetation, or water courses. (3) Poisonous dusts must not be disseminated. (4) It is advisable that the factories, workshops, etc., should be at a distance from human habitations.

(B) *As regards factories, workshops, etc.*—(1) Ample space, efficient ventilation, and means for the extraction of dust should be provided. (2) Thorough cleansing is essential. (3) Proper construction, especially of floors, is necessary. (4) Efficient lavatory accommodation, including baths, is required. (5) A special, detached mess-room should be the rule.

(C) *As regards operatives*.—(1) Preliminary and regular medical inspection. (2) The exclusion of debilitated workers, and those with skin abrasions. (3) Cleanliness, and attention to the hair, nails, and teeth, especially prior to meals. In men the hair should be kept short and the face clean shaved. (4) The frequent taking of warm baths. (5) The avoidance of eating in workrooms. (6) The avoidance of working on an empty stomach. (7) The wearing of overalls or the changing of clothes. (8) The avoidance of any alcoholic excess.

In addition, it is to be noted that in the case of lead workers the water used for washing should contain hypochlorite of soda or paraffin; if possible, gloves, and in some cases respirators, should be worn; milk should be freely consumed, but must not stand uncovered in the workshop, while it is a good plan to administer a little sulphur with the milk.

Further, the floors of workshops should be kept moist with a solution of chloride of calcium, while restriction of female labour, abolition of lead handling, and the substitution of electrolytic manufacture or the MacIvor ammonia process must all tend to diminish industrial plumbism. Notification of every factory and workshop case to the Home Office is required by law.

Special Methods.—Ore Smelters must not remove lead from the condensers till every part of them is completely cooled. Free ventilation and hoods in front of the furnaces during the smelting process minimise danger, but there is also risk in the cleansing of the flues.

White Lead Workers.—These are the operatives who most frequently suffer from plumbism, and great care has to be exercised in white lead factories. Five modes of manufacture are in vogue, namely—

(*a*) *The Dutch method*, in which lead is converted into the subacetate by means of volatile acetic acid. The carbonate (white lead) is then obtained from the subacetate by the action of carbon dioxide gas generated from tan. The carbonate is removed on trays, rolled, dried, ground, washed, and desiccated to a fine powder.

(*b*) *The French, or Thénard's method*.—The white lead is obtained directly from the action of carbon dioxide gas on litharge, which is dissolved in water by the aid of acetic acid.

(*c*) *Birmingham method.*—This is similar to Thénard's method, the carbonic acid being derived from the combustion of coke.

(*d*) *Hannay's method.*—Sulphate of lead is prepared from the sulphide galena, which is volatilised and oxidised in a furnace. The vapours are passed through a spray condenser, and the sulphate is precipitated on cooling. In this method improved machinery has obviated the necessity for handling.

(*e*) *MacIvor process.*—Lead ore containing a carbonate is roasted at a low temperature. An oxide is formed, and this is washed by a special machine and thus separated out. It is then dissolved in a cold solution of acetate of ammonia. Acetate of lead is formed, and the free ammonia remains dissolved in the water. The acetate is then decomposed by CO_2, carbonate of lead, and acetate of ammonia resulting.

The Dutch is the most dangerous and yet the most commonly employed method, women being chiefly affected.

Risk is to be combated by the inunction of the hands and face with oil, the wearing of gloves, wet roller grinding, and the use of covered shoots instead of hand-borne trays.

The grinding should be combined with the removal of any dust by means of exhaustion into a moist chamber. Grinding with oil to form a paste would obviate many of the dangers resulting from use in the powdered form. Clothes should be worn tight-fitting at the neck and wrists, and, if overalls are not provided, should be changed when work is over for the day or night.

Red Lead Workers.—The dangers to them arise through the dust or vapours from the furnaces and the dust from minium (red oxide of lead) grinding. It is to be prevented by protecting the mouth and nose by sponges or cotton-wool, and conducting the grinding in closed chambers having impermeable joints.

Potters come into contact with lead in the glazing process, nearly all glazes containing lead compounds. The employment of glazes made without lead, or containing only a little lead, is likely to improve the health of pottery workers. The use of "fritted" lead (silicate), or a double silicate, is attended with much less danger than that of the carbonate.

File Makers.—The danger to file makers arises from the fact that they are accustomed to hammer their files upon lead cushions. File makers should avoid licking their fingers, as they are in the habit of doing. The lead is said to gain access through the sweating skin. Respirators should specially be worn in this occupation, or another form of hammering cushion be substituted for the leaden variety.

Glass-cutters absorb lead from the glass dust, the glass containing lead; and Wood Polishers from the lead-containing glass in sandpaper.

Type-setters should not hold types in their mouths.

The danger to Weavers arises from the wearing down of the leaden weights or lingoes attached to the harness cords of the looms. Iron lingoes ought to be employed, and are coming largely into use. A further danger is the sucking of threads dyed yellow with lead chromate.

In the case of Calico Dyers, those working with the chrome salts of lead run most risk. Improvement of the processes and substitution of less poisonous compounds are required as well as fan ventilators.

House Painters absorb lead in two ways—(*a*) when burning off old paint; (*b*) when smoothing a rough surface of freshly dried paint with sandpaper. While engaged in these occupations, house painters should wear respirators. The mere painting process is not dangerous.

Dressmakers and Tailors may absorb lead by sucking silk thread weighted with the acetate to facilitate the threading of needles. The thread should, if possible, be weighted with some innocuous substance.

Phosphorism.

Syn., Chronic Phosphorus Poisoning.

Incidence as to Trades.—Makers of phosphorus and phosphor bronze. Match makers.

Incidence as to Individuals.—Persons with decayed teeth are liable, and, in the case of match factories, young women and children.

Mode of Access.—Phosphorus invades the system chiefly by the respiratory tract, but also by the alimentary system and by carious teeth.

Symptoms.—Cachexia, anæmia, fatty degeneration, yellow skin, garlicky smell of the breath and urine, albuminuria, tendency to abortion, and bone necrosis as seen especially in the "phossy jaw" of match-making operatives. Phosphorism is slow in developing, three or four years elapsing before it exhibits itself.

Mortality.—If remedial measures are not undertaken, early death results in the long run.

Prevention.—The general methods are those previously detailed (p. 104), with, in addition, the exclusion of phthisical workers and any having carious teeth. Fume extraction is specially required. Notification to the Home Office.

Special Method.—*Phosphorus preparers* suffer but little, as the phosphorus is kept constantly wet. The fumes should be conducted into water, and thence to a chimney. The retort workmen should have their eyes, noses, and mouths protected, while aspirators should be employed in the workrooms to draw the heavy vapour upwards. The number of persons concerned in this industry is small.

Match making, on the other hand, is of great importance, and requires detailed consideration. In this industry two forms of phosphorus are used, the yellow and the red or amorphous. Of these the former is poisonous, while the latter is not toxic, and would always be used if its preparations were as inflammable as those of yellow phosphorus. It is employed in the "strike on the box" matches, being found in the box paste. The manufacture of "strike anywhere" matches, in which yellow phosphorus is the essential ingredient, is dangerous at several stages, namely, mixing, dipping, drying, and boxing.

Mixing.—Phosphorus paste consists of a mixture of yellow phosphorus, (which forms 6 to 10 per cent. of the whole), chlorate of potash and glue, with gritty materials and colouring agents. The components are first ground, and then mixed in liquid glue.

Dipping.—The long double matches, in bundles or set in frames, are dipped at one end, after being treated with some adhesive substance, such as paraffin, wax, or stearin.

Drying.—After one end has been dipped, the matches are carried in trays to a drying chamber, where they remain for a varying period; then the other end is dipped, and a second drying process undergone.

Boxing.—After being cut in two, the matches are boxed by hand.

In all these processes the chief danger arises from the fact that phosphorus vaporises; oxidising in the air or on ignition, and forming white fumes containing phosphorus, phosphorus acid, and phosphoric acid, which are inhaled by the work-people, and come in contact with parts liable to be affected, such as the jaw. The lower oxides are by far the most dangerous, and are mostly formed when the temperature is normal or low. To a lesser extent the perpetual handling may convey the poison to the system.

Recommendations for the prevention of these dangers:—

(*a*) The mixing should be done in closed vessels with safety-valves, and the percentage of phosphorus in the paste regulated. (*b*) The immediate removal of fumes by hoods placed over the dipping tables. (*c*) The employment of trolleys between the dipping and drying rooms, so that no one need be any length of time in the latter. (*d*) Exclusion of children and young persons who are likely to be careless. (*e*) The wearing of overalls. (*f*) The systematic gargling with antiseptic or alkaline mouth-wash, and frequent use of the tooth-brush, especially after meals. (*g*) The presence of turpentine or essential oils in the workroom to favour oxidation of the phosphorus. (*h*) The employment of an aqueous solution of copper sulphate, which forms with phosphorus a phosphate precipitated along with metallic copper. (*i*) The use of absorbents, such as charcoal. (*j*) The careful storage of phosphorus in glass or stoneware vessels containing water. (*k*) Complete suppression of the use of yellow phosphorus.

Mercurialism.

Syn., Chronic Mercury Poisoning.

Incidence as to Trades.—Mercury miners, ore smelters, mirror silverers (old method), philosophical instrument makers, electric battery makers, photographers, telegraphists, artificial flower makers, water gilders, taxidermists, hat makers, bronzers, furriers, and skin dressers.

Incidence as to Individuals.—Idiosyncrasy has to be noted.

Mode of Access.—Mercury enters the system as a vapour, or as a fine metallic dust, the respiratory, alimentary, or integumentary systems being primarily affected. After prolonged handling of the metal, the skin tends to become creased, and the creases retain the fine particles.

Mortality.—It is greatest in mercury miners, as seen in Spain.

Prevention.—*General Methods.*—Apart from those already detailed (p. 104), the temperature of the workroom should be low, as the danger increases with the elevation of temperature. In ventilating, the outlets should be placed below, the vapour being heavy. The floors should be impermeable, sloped, and guttered, and tinfoil may be placed on them to secure an amalgam and prevent volatilisation. When there are no operatives in the room, ammoniacal vapours may be diffused through them. This is purely empirical.

As regards the workers, they should wear paper caps and gloves, drink plenty of milk, or milk with sulphur, and wear respirators containing sponges impregnated with sulphur, or soaked in solution of silver nitrate. Sulphur baths are useful, and special attention should be paid to the teeth and to rinsing out the mouth with chlorinated water. Finally, mercury should always be stored in covered vessels. Every factory and workshop case must be notified to the Home Office.

Special Methods. — In the case of Ore Smelters, the condensing chambers and flues must be so arranged as to prevent the escape of gases.

Mirror Silverers should use flannel wrapped round a rod when spreading the metal on glass.

Water Gilders, when coating small articles, should have these enclosed in special chambers so constructed as to admit only the hands.

Cupralism.

Syn., Chronic Copper Poisoning.

Incidence as to Trades.—Ore smelters, coppersmiths, copper cleaners, brassfounders, clock makers.

Mode of Access.—Copper gains entrance by the respiratory and alimentary tracts, and possibly by the skin, but it is by no means a very poisonous metal from an industrial point of view. The zinc, so commonly associated with it in workshops, probably plays a greater part than the copper in producing noxious symptoms, especially those seen in the case of brassfounders.

Symptoms.—A green line on the gums and teeth, colic, so-called "brassfounders' ague," bronchitis, and asthma. Green coloration of the hair, teeth, and bones.

Prevention.—Those general methods detailed in the table (p. 104).

Zincalism.

Syn., Chronic Zinc Poisoning.

Incidence as to Trades.—Zinc smelters (spelter workers), brassfounders, zinc grinders, colour mixers, calico-printers, glass decolorisers, manufacturers of artificial meerschaum pipes, iron galvanisers, and champagne bottle wirers.

Mode of Access.—Zinc enters the system by inhalation of the vaporised oxide or of the dust. It is not absorbed by the skin, while its emetic action renders absorption by the stomach unlikely.

Symptoms.—Cough, dyspnœa, headache, giddiness, sweating, stiffness and cramps in the limbs, nausea, vomiting, night blindness, hyperæsthesia, followed by paresis and the so-called "brassfounders' ague."

It must be noted that many of these phenomena are probably due to other metals combined with the zinc.

Mortality.—It is trifling. Zinc smelters, however, are short lived, and suffer from catarrh and a form of myelitis.

Prevention.—Beyond the tabulated general methods, little need be said. Zinc vapours should be condensed, and milk drinking is useful.

Special Methods.—Closed chambers should be used in zinc grinding.

Arsenicalism.

Syn., Chronic Arsenical Poisoning.

Incidence as to Trades.—Ore miners, zinc smelters, cobalt extractors, dye and colour workers; makers of cosmetics, artificial flowers, toys, wall-papers, fly-papers, sheep dips, and confectionery; chromo-lithographers, furriers, tanners, fell-mongers, taxidermists, and shot makers.

Incidence as to Individuals.—A certain amount of idiosyncrasy has to be noted. Old people are very susceptible.

Mode of Access.—Arsenic invades the body through the alimentary, respiratory, and integumentary systems, chiefly in the form of arsenious acid, but also as arseniuretted hydrogen.

It is excreted largely in the urine, and stored up in the hair and horny tissues of the body.

Symptoms.—They are characteristically remittent, and consist in thirst, pain on deglutition, nausea, vomiting, diarrhœa, skin eruptions, and cutaneous pigmentation frequently affecting the skin of the abdomen, multiple peripheral neuritis, and general cachexia.

Mortality.—It is probably trifling.

Prevention consists in applying those general rules common to all poisonous metals (p. 104). In addition, cases of arsenical poisoning occurring in a factory or workshop have to be notified to the Home Office.

Special Methods.—As arsenic may gain access to the ground water, and either in this way or directly contaminate water supplies, arsenical compounds in factory effluents, etc., must not be discharged into sewers or streams, or indiscriminately on any land.

Special leather suitings and head-pieces should be worn by the workmen cleaning flues containing arsenious acid. Short of this, plugging the nostrils, covering the mouth, and powdering exposed skin surfaces with fullers' earth are devices commonly employed.

Suitable closed condensation chambers should be provided, and high chimneys with buttresses in the flues, while occasional chemical examination of the escaping vapours ought to be conducted.

Where possible, innocuous colouring matters must be substituted for those containing arsenic, and in artificial flower-making, the process of fluffing, *i.e.* sprinkling with dry Scheele's green, should be replaced by some safer method, such as mixing with collodion, etc.

Antimonialism.

Syn., Chronic Antimony Poisoning.

Incidence as to Trades.—Ore smelters and type-founders.

Incidence as to Individuals.—Peculiar idiosyncrasies must be noted.

Mode of Access.—The metal gains entrance through the respiratory, alimentary, and integumentary systems, but industrial antimony poisoning is very rare.

It is largely eliminated in the urine.

Symptoms.—Herpetic skin eruptions, due to excessive perspiration, as seen in ore smelters. Colic, gastro-intestinal disturbances, vesical and urethral pains.

Mortality.—Trifling.

Prevention.—The usual general methods (p. 104). Notification of cases to the Home Office is not required.

Special Methods.—Ore smelters should sponge the skin with solutions of bicarbonate or biborate of soda, boracic acid, or bismuth.

Carbolism.

Syn., Carbolic Acid Poisoning.

Incidence as to Trades.—Phenol manufacturers.

Mode of Access.—By the respiratory and integumentary systems.

Symptoms.—A feeling of suffocation, unconsciousness, brown staining of the skin, vertigo, headache, debility, and carboluria.

Mortality.—Trifling.

Prevention.—More or less as for poisonous metals (p. 104).

Bromism.

Syn., Acute and Chronic Bromine Poisoning.

Incidence as to Trades.—Bromine manufacturers.

Mode of Access. — By the respiratory system, the vapours being inhaled. The chief danger arises when stone receptacles are being emptied and filled.

Symptoms.—Irritation of mucous membranes, with increased secretions, cough, malaise, vertigo, laryngeal spasm, and asphyxia. A chronic asthmatic condition prevails amongst bromine workmen.

Mortality.—Trifling.

Prevention.—Proper storage of bromine and transport in the form of bromide of iron, free ventilation, protection of the mouth and nose. Exclusion of alcoholics and those predisposed to respiratory disease. Prevention of the pollution of water supplies and streams by the effluent containing bromine is important, while the vapours should be condensed to prevent injury to vegetation.

Chlorinism.

Syn., Acute and Chronic Chlorine Poisoning.

Incidence as to Trades.—Bleach work operatives.

Mode of Access.—By the respiratory and integumentary systems.

Symptoms.—In the acute form there is laryngeal spasm. In the chronic, bronchial irritation, acid dyspepsia and dental decay, papular skin eruptions, anæmia, anosmia, and loss of flesh.

Prevention.—Free ventilation and avoidance of concentrated vapours, the wearing of a protective helmet, and inunction of the skin.

Iodism.

Syn., Acute and Chronic Iodine Poisoning.

Incidence as to Trades.—Iodine manufacturers.

Mode of Access.—By the respiratory and integumentary systems, the dangerous stages being those of distillation and sublimation, while the filling and emptying of the receptacles constitutes a further risk.

Symptoms.—Respiratory irritation, frontal headache, coryza, and syncope. In acute cases there is apt to be a caustic action on the skin, especially if it be abraded, while in chronic poisoning a persistent cold in the head, liable to acute exacerbations, is a leading symptom.

Prevention.—Air-tight distillation retorts are required. The fumes of sulphuretted hydrogen should be extracted. Free ventilation, combined with protection of the mouth and nose.

Chromism.

Syn., Chronic Chromium Poisoning.

Incidence as to Trades.—Chromium manufacturers, colour makers, glass and porcelain painters, dyers and textile printers, chemical manufacturers.

Mode of Access.—By the integumentary and respiratory systems.

Symptoms.—The so-called chrome sores affecting the skin and mucous membrane. The nasal septum becomes affected, and there is sanguineous discharge and rapid formation of ulcers which may perforate.

Prevention.—The general methods are the same as those employed in the case of the poisonous metals (p. 104). In addition, the use of snuff is recommended.

Cyanide of Potassium Poisoning.

Incidence as to Trades.—Electroplaters and photographers.

Mode of Access.—Inhalation and absorption through skin abrasions.

Symptoms.—Vertigo, headache, muscular weakness, and exhaustion.

Prevention.—Free ventilation. The maintenance of a low temperature in the workshops. Protection of sores.

Carbonic Oxide Poisoning.

Acute and chronic.

Incidence as to Trades. — Plumbers, braziers, tinmen, tinkers, lace makers, stick makers, miners, and ammonia workers.

Mode of Access.—Inhalation. Five per cent. is toxic.

Symptoms.—Of the acute: coma and asphyxia. Of the chronic: husky voice, headache, vertigo, nausea, vomiting, drowsiness, anæmia, and debility.

Prevention.—Of the acute variety, seen in the case of miners encountering "after damp": ventilation of mines, supplies of oxygen kept in readiness, and the use of mice as diagnostic tests of the state of the air. Of the chronic variety: free ventilation of workshops; the use of proper stoves, in which iron does not become red-hot, and in which there is efficient fume outlet. In lace makers the danger arises from burning coke beneath the lace frames as a means of warming the hands and increasing tactile sensibility. Such a practice should be discontinued, and the factories or rooms properly heated.

Bisulphide of Carbon Poisoning.

Chronic.

Trade Incidence.—Vulcanisers and indiarubber workers.

Mode of Access.—Inhalation of the vapour. Cutaneous absorption of the mixture of chloride of sulphur and bisulphide of carbon.

Symptoms.—There are two stages—(*a*) *Excitation*; (*b*) *collapse*.

(*a*) This consists of headache, vertigo, insomnia, cramp, and even epileptiform convulsions. (*b*) This is characterised by depression, drowsiness, sexual excitement, anæsthesia, muscular paresis, analgesia, amaurosis, atrophy of the testes, and in women, a tendency to abortion. They often resemble those of general paralysis of the insane, or it may be acute mania, or alcoholism.

Prevention.—Ample working space. Free ventilation, with the outlets placed low to remove the excess of the heavy vapour. The use of mechanical contrivances to obviate the risk of handling the mixture. The employment of other processes for treating rubber.

Pneumoconiosis.

Pathological pulmonary conditions induced by dust.

Trade Incidence.—Stone masons, especially "gannister" workers, coal miners, steel grinders, potters, Portland cement makers, tin miners, quarrymen, workers in wool, cotton, flax, and shoddy. Also makers of grindstones and sandpapers, button makers, mother-of-pearl and ivory workers, pin pointers, electroplate workmen, and operatives in tobacco factories.

Mode of Access.—Inhalation.

Symptoms.—Bronchial irritation and occasional bronchitis, morning cough, expectoration, cachexia, and the phenomena seen in those suffering from fibroid phthisis.

Early expectoration, hæmoptysis, aphonia, fever, and diarrhœa are usually absent in pneumoconiosis.

Types.—*Silicosis*, including "gannister disease," acquired by those mining, grinding, or making bricks from a hard siliceous rock.

Anthracosis due to coal dust and carbon particles.

The other types are not distinctive.

Mortality.—Considerable. The disease runs a long course, but is much more rapid in "gannister" workers.

Prevention.—Many of the general rules stated in the case of the poisonous metals are applicable to these trades.

In addition, the habitual use of respirators, wet grinding, and the employment of automatic machinery, are advisable.

DISEASES DUE TO IMPURE AIR APART FROM DUST AND POISONOUS VAPOURS.

Phthisis and Respiratory Diseases.

Trade Incidence. — Bookbinders, printers, tailors, hatters, and hair dressers.

Alcoholism.

Special Trade Incidence.—Innkeepers, hotel servants, and publicans.

DISEASES DUE TO DYES.

The effects fall chiefly on the alimentary, respiratory, nervous, urinary, and integumentary systems, and are mainly produced by certain of the coal tar colours. Some of the mordants employed are also poisonous.

Trade Incidence.—Dye workers, dyers, colour printers, and operatives in textile factories.

Symptoms.—These vary with the system affected.

Alimental. — Gastro-intestinal irritation with vomiting and diarrhœa. Anilin workers are said to suffer from habitual constipation.

Respiratory.—Dyspnœa is frequent.

Nervous.—Headache, neuralgia, stupor, and tonic and clonic spasms.

Urinary.—Albuminuria.

Integumentary.—Erythema, eczema, ulcerations, and abscess formation. Individual dyes vary much in their action, which largely depends on their chemical constitution.

Prevention.—The exclusion from the factories of workers liable to be affected by dyes, as idiosyncrasy is common.

The use of gloves and, in some cases, of respirators is important, otherwise the rules applicable in the case of the poisonous metals apply to dyes (p. 140).

The fouling of streams by the effluents from dyeworks is an important question, especially with regard to their effect on fish life. Settling tanks, strainers, and filter beds should be employed to render the effluents as far as possible harmless before they are discharged.

DISEASES ASSOCIATED WITH THE MANUFACTURE AND USE OF EXPLOSIVES.

Trade Incidence.—Miners, quarrymen, operatives in the factories. The effect is produced through the respiratory system.

Symptoms.—Headache, giddiness, dyspnœa, and debility.

Prevention.—Ordinary common-sense precautions suffice.

The other diseases prevalent amongst the work-people engaged in special trades do not closely concern the medical officer of health; but as he is primarily responsible for the supervision of *bakehouses*, he should know that bakers are liable to suffer from erysipelas and "baker's itch," a form of eczema due to cutaneous irritation by the flour. They are also subject to colds and rheumatism, their respiratory tracts being exposed to dust and the fumes of coal, while they undergo frequent and sudden changes of temperature, and often work in damp surroundings. Bakehouses, therefore, should be specially built for the purpose of baking, the rooms being lofty, well lighted and ventilated, and separate rooms should be provided for the different processes. The baking ovens are best heated by gas or superheated steam.

IV. DISEASES OF ALIMENTATION.

I. From Deficiency of Food.
II. From Excess of Food.
III. From Injurious Food.
 A. Diseased foods { Animal. / Vegetable. }
 B. Contaminated foods.
 C. Ill-balanced dietary.

I. FROM DEFICIENCY OF FOOD.

Famine.

Geographical Distribution.—Sporadic cases are world-wide. Special interest attaches to the subject from the ravages produced by repeated famines in India. Famine specially affects teeming populations dependent on agriculture.

Etiology.—As regards famine, the cause is usually to be found in war, pestilence, and in meteorological conditions interfering with the means of subsistence.

II. FROM EXCESS OF FOOD.

An excessive quantity of food in all its constituents produces dyspepsia, constipation, torpor, and eventually crapulous diarrhœa. Prolonged indulgence results in a toxæmia accompanied by fever, fœtid breath, and sometimes jaundice.

III. FROM INJURIOUS FOOD.

A. DISEASED FOODS.

(1) ANIMAL.

Pneumonia, tubercle, anthrax, possibly enteric fever, and various parasitic diseases, such as trichinosis and hydatids, may all be caused by the ingestion of diseased meat, and have already been partly discussed from the point of view of preventive medicine.

Milk may give rise to disease, either in the condition in which it is drawn from the animal, *e.g.* tubercle, or as the result of subsequent contamination or decomposition, *e.g.* enteric fever, ptomaine poisoning, or the toxic effects produced by the *B. enteritidis sporogenes*, an organism of sewage. This is a spore-bearing, milk-curdling, gas-forming, and acid-producing bacillus, which is, as a rule, motile. It has been found in milk which produced violent diarrhœa, and is best isolated from milk by raising the temperature of the milk to 80° C. for a quarter of an hour, then incubating at 37° C., and cultivating anaerobically. The serum of such milk contains the bacilli, and speedily kills guinea-pigs (Plate VI. Fig. 5).

Gastro-intestinal derangements may be produced by eating the flesh of animals dead of swine fever, joint-ill, cattle plague, and other diseases. If the muscles themselves be not diseased, thorough cooking apparently prevents bad effects, but it is advisable to condemn such meat as unfit for human consumption. Somewhat similar effects may be produced by the ingestion of meat undergoing the process of putrefaction, derived from animals killed by lightning, by accidents, or the victims of acute inflammatory disease or exhaustion quite apart from the action of any known ptomaine. Further, idiosyncrasy has always to be borne in mind. Thus mutton is poisonous to some people, while others cannot partake of shell-fish without becoming ill. Indeed, certain forms of fish and shell-fish may constantly act as toxic agents, apart from any question of idiosyncrasy. Nervous symptoms resembling curare poisoning have been produced by oysters and mussels. Several forms of micro-organism have been described in meat which has produced gastro-intestinal derangements of the nature of ptomaine poisoning.

(*a*) *B. enteritidis* of Gaërtner, found in the flesh of a cow suffering from diarrhœa, and obtained from the spleen of a man who died after eating the cow's flesh. It is a bacillus closely resembling the *B. coli communis*, and kills mice fed upon it, while it is fatal to rabbits and guinea-pigs by subcutaneous injection.

(*b*) The "Welbeck" bacillus, so called because it is supposed to have been the active agent in epidemics of illness at Welbeck and Nottingham, the result of eating ham. It is a motile bacillus, which may possess a bright oval spore, situated centrally or terminally, and it is pathogenetic to animals.

(*c*) *B. proteus, coli communis, subtilis, prodigiosus*, the *Bacterium termo*, and the *Staphylococcus pyogenes aureus*, have all been found at different times in poisonous meat.

Botulismus.

This is a form of food poisoning usually induced by means of sausages.

Geographical Distribution.—It is most common on the Continent. An epidemic occurred in Belgium in 1895.

Etiology.—It is due to a toxine formed in the flesh by the action of the *B. botulinus* of Van Ermengen. This is an anaerobic, slightly motile, flagellated, ovoid micro-organism which forms terminal spores, and was found in ham which showed no signs of putrefaction.

Cultural Characteristics.—It grows best in alkaline media at 27° C., and rapidly liquefies gelatine. The colonies are large, round, and transparent, and yield only a faint, not unpleasant odour. It is pathogenetic to mice, cats, and guinea-pigs; producing a powerful toxine.

Description.—The *incubation period* varies, but is usually twenty-four to thirty-six hours. It may, however, be wholly absent.

Symptoms.—These are nervous and gastric, the former being the most marked. The onset is sudden. There may be an initial rigor or giddiness, followed by pain in the stomach, vomiting, and constipation. Great thirst and a feeling of constriction in the throat ensue, and such evidence of implication of the nervous system as ptosis, diplopia, and aphonia. Muscular twitchings are not uncommon, and coma may herald death, which occurs in a few days. Recovery is the rule, but some of the nervous phenomena may persist for many months.

Differential Diagnosis. — Distinguish from arsenical and aconite poisoning and septicæmia.

Mortality.—It is about 10 per cent., but depends on the amount of toxine absorbed.

Method of Acquisition.—The ingestion of raw pig meat, the muscular tissue alone containing the toxine. The toxine is distinct from those produced by ordinary putrefactive organisms.

Prevention.—The thorough cooking of all meat, especially sausages and pork. It is to be noted that pickling in strong brine will not destroy the toxine or spores.

Ptomaine Poisoning.

That is to say, the toxic effects produced by certain substances called ptomaines, which may be formed during the decomposition of nitrogenous material. The ptomaines belong to the class Amines, organic chemical compounds related to ammonia, and containing carbon, hydrogen, nitrogen, and sometimes oxygen. They are not all toxic. Thus trimethylamine, found in herring brine, is harmless; while muscarin, occurring in decomposing fish, and tyrotoxicon, sometimes present in milk and cheese, are extremely poisonous agents.

Etiology.—Ptomaine poisoning is due to the consumption of animal food in a certain intermediate stage of decomposition. The ptomaines are transition products in the conversion of complex nitrogenous compounds into simpler groups. This chemical action is due to certain organisms constantly associated with the process of putrefaction, such as staphylococci and *Proteus vulgaris*.

A considerable amount of confusion still surrounds this difficult subject, and the term ptomaine poisoning at the present time includes symptoms produced by—(1) The organism alone. In this case the organism may exist naturally in the human body, and take on a virulent character, or it may be introduced from without. (2) The organism plus its ptomaine. Here the ptomaine is manufactured in the human body, or in the food prior to ingestion. (3) The ptomaine alone, in which event the ptomaine is developed in the food before ingestion, and is the sole cause of the toxic symptoms.

Description.—*Incubation period.*—This varies according to the nature of the micro-organism and the manner in which it gives rise to its toxic effects. Thus the incubation period is longest in class 1, shortest in class 3, while class 2 holds an intermediate position. It may be only a few hours or as long as two days.

Symptoms.—As these depend on divers organisms and ptomaines, they are by no means constant, but the usual phenomena are thirst, pain, vomiting, vertigo, and diarrhœa. The diarrhœa is irritative, and the stools may contain blood. There is febrile disturbance and great prostration. Sometimes nervous symptoms are prominent; at others, there may be skin eruptions or anuria. Convalescence is frequently tedious; and if death occurs, it is commonly ushered in by coma.

Differential Diagnosis.—Distinguish from arsenical and aconite poisoning, septicæmia, and cholera.

Mortality.—Death is not infrequent, though recovery is the rule.

Method of Acquisition.—Ptomaine poisoning in the large majority of cases is associated with the eating of pig's flesh in one form or another. The meat may be infected either before or after cooking, and cooking, though it may kill the ptomaine-forming organism, does not chemically alter the ptomaine already developed. As has been pointed out by Ballard, cooked pork contains a large amount of gelatinous material, which possibly forms an excellent culture medium for micro-organisms, and explains the great frequency of poisoning with pig flesh.

Food, at one time poisonous, may at a later period lose its toxic properties, as a result of chemical metabolism of the ptomaine, the death of the micro-organism, and the consequent cessation of ptomaine production. Further, one part of the meat may be harmless, while another is harmful, the ptomaine having only been produced in certain portions, or the organism not being present throughout.

Continental pork sausages are *par excellence* the home of meat ptomaines. So much is this the case, that a special name, *Allantiasis*, has been applied to sausage poisoning, and one of the toxic substances is known as *Allanto-toxicon*. It is most frequent in those sausages containing liver and blood. Blunzen, a form of Würtemburg sausage, is peculiarly liable to cause poisoning, owing to its being prepared by a method favouring putrefaction. Pork pies, cold pork, pork gravy, and brawn have all in turn caused serious symptoms.

In addition, any form of meat may by ptomaine formation be rendered hurtful. Neuridine ($C_5H_{14}N_2$), neurin ($C_5H_{13}NO$), and choline ($C_5H_{15}NO_2$) are all varieties of ptomaine found in meat. Neuridine is probably non-toxic, while the other two are poisonous.

Pies of any kind are dangerous if no aperture be left in the crust, and tinned and canned meats of all kinds are liable to contain ptomaines, owing to the want of proper cooking, the inclusion of bacilli, the exclusion of air, and the arrest of those natural chemical processes which tend to render ptomaines harmless. Decomposing fish and molluscs are fruitful sources of food poisoning, containing, as they may, such ptomaines as gadinin ($C_7H_{17}NO_2$), muscarin ($C_5H_{15}NO_3$), and mytilo-toxine ($C_6H_{15}NO_2$). Ptomaines may develop in other foods derived from animal sources, such as milk, butter, or cheese. The best known is tyrotoxicon, a butyrate of diazo-benzene, and allied to the colouring matter Bismarck-brown. In all probability, however, it is not the most frequently present, nor is it the most active.

The *symptoms* of tyrotoxicon poisoning are giddiness, diplopia, nausea and vomiting, gastric pain and intestinal colic, diarrhœa, and prostration. The pupils are dilated, and there is often formication. The illness may end in death.

Prevention.—Under this heading, it is important to remember that meat, fish, milk, or cheese containing the most deadly ptomaine, may appear perfectly good, there being no sign of putrefaction or inflammatory change. Further, as once the ptomaine has developed, cooking may be powerless to alter its toxicity, it will be apparent that it is impossible in some instances to foresee and obviate the danger.

Attention, however, has to be directed to preventing the least opportunity of ptomaine development, and in this direction much may be done by—

1. *Selection of food.*—Meat, fish, and even game should be eaten fresh, if at all possible. Frozen meat is, however, both safe and palatable, and is much to be preferred to canned food.

Indiscriminate indulgence in sausage food is to be deprecated, though the danger is less in this country than abroad, owing to the fact that in Britain better materials are employed and greater cleanliness observed.

2. *Cooking of food.*—This is of prime importance, especially in the case of pig flesh, fish, and molluscs.

Pickling or smoking does not guarantee the absence of ptomaines.

3. *Storage of food.*—Care must be taken both in the case of raw and prepared food. In most instances of epidemic poisoning it has been found that the food before consumption had been stored in places where it was exposed to drain emanations. The use of sanitary larders is thereby indicated.

4. *Inspection and regulation of food.*—Strict and persistent enforcement of the provisions of the Public Health Act relating to unsound food (pp. 519, 588) and slaughter-houses (pp. 533, 585). There should be regulations forbidding the preparation of such manufactured meat-stuffs as sausages, "black puddings," etc., from unsuitable and dangerous material. In the case of an epidemic, the medical officer of health may be called on to ascertain the source of infection, and he must form an opinion as to the particular article of food which has caused the mischief. This is best done by the use of eliminative tables, on which are set down the names of all the persons, whether poisoned or not, who took

part in the meals preceding the symptoms, and each article of food and drink consumed, and the amount of each devoured. For example—

DINNER.

	Soup.	Fish.	Entrée.	Joint.	Game.	Sweets.	Ice.	Cheese.	Dessert.	Coffee.	Water.	Wine.	Aerated Waters.	Spirits.	Liqueurs.
Escapes, A .	+	+	+	0	+	+	0	+	0	+	0	0	+	+	+
Ill, B . .	+	+	+	+	+	+	+	+	+	+	0	+	0	0	+
Ill, C . .	+	+	+	+	+	+	0	+	+	+	0	+	+	+	+
Escapes, D .	+	+	+	0	+	+	0	0	+	+	0	+	0	0	+
Ill, E . .	+	+	+	0	+	+	+	0	+	+	+	0	0	0	0

From the above table one may perhaps wonder how any escaped illness; but it will be seen, if one carefully considers the matter, that the joint and ice were at fault. Such a conjunction would lead one to suspect the larder. If there was a suspicion that the joint had been affected before reaching the house, the medical officer of health would require to inspect the remainder of the carcase and the hygienic relations of the butcher's shop or slaughter-house.

5. *Notification of cases* might with advantage be made compulsory.

(2) VEGETABLE.

Various forms of parasite already considered may gain access to the body through the medium of raw or imperfectly cooked vegetable food, while, as stated, actinomyces may be conveyed by barley. Dyspepsia, accompanied by flatulence and diarrhœa, frequently follows the ingestion of decomposing vegetable substances, such as fermented flour or flour containing fungi. The special diseases produced by injurious vegetable foods are ergotism, pellagra, lathyrism, and mushroom poisoning.

Ergotism.

Geographical Distribution.—It is endemic in Russia, and is found occurring in central Europe and France. In early and mediæval times it was a veritable scourge in many parts of the Continent.

Etiology.—It is due to the poison of a grain parasite which specially tends to affect rye. This parasite is a fungus, the *Claviceps purpurea*, which produces the condition known as ergot of rye and the disease called *ergotism*, owing to its containing sphacelinic acid, ergotinic acid, and cornutin. The rye flowers become infected with the spores of this fungus, which grow and ripen, absorbing the rye grain, and forming in place of the grain a black horny growth composed of a mycelium—the ergot. The disease is produced by the inclusion of the ergot in rye flour along with the healthy rye grains.

Life-cycle of the Claviceps.—The ergot lies dormant throughout the winter, but under suitable conditions, such as warmth and moisture, it shoots out from its surface little club-shaped formations, each with a purple head and a white stem. This stage is the true *Claviceps purpurea.* The purple heads have pitted surfaces, the little elevations corresponding to the positions of ascocarps, receptacles containing asci or cysts which hold the ascospores. The asci escape from the purple heads, and the spores from the asci. The free spores are borne by the wind to the rye flowers, where they fasten on the ovary and form a delicate mycelium, which in its turn produces spores called gonidia. These gonidia, lying in sweet adhesive material known as honey-dew, attract insects, which carry them to other rye flowers, and the process is repeated. The rye ripens, the mycelium becomes thicker, and finally invades and absorbs the whole rye grain, producing the typical black ergot, the so-called spurred rye (Figs. 68, 69, and 70, p. 226).

Description.—Symptoms.—The acute form of ergotism is characterised by vertigo, depression, angina, colic, tympanites, vomiting, purging, cramps, it may be convulsions, and frequently death in one or two days. Convalescence is prolonged, and may be punctuated by relapses and sequelæ. The symptoms of the chronic form are formication, severe burning pain in the limbs, followed by anæsthesia, skin eruptions, lividity and gangrene, which spreads from the limbs to the trunk. The gangrene is commonly dry, and there is little hæmorrhage on separation of the necrobic part, owing to the contraction and obliteration of arteries.

Differential Diagnosis.—Distinguish from epidemic erythema, tetany, Raynaud's disease, and erythro-melalgia.

Types.—Spasmodic or convulsive and gangrenous.

Mortality.—10 to 60 per cent. It varies with the epidemic. The acute form is usually fatal.

Incidence.—Age.—The acute form is most common in children. Ergotism does not affect children at the breast.

Sex.—Indifferent.

Season.—Winter.

Method of Acquisition.—Ingestion of infected rye in the form of bread or cakes.

Prevention.—The disuse of ergoted flour, which should always be condemned. The presence of ergot may be detected by methods detailed on p. 240.

The improvement of the condition of the labouring classes in countries where ergotism is prevalent, as poverty and poor food predispose to the disease.

Pellagra.

Geographical Distribution.—It is endemic in northern Italy, Roumania, southern France, especially the Landes, and northern Spain.

Etiology.—The disease is produced by eating maize which has undergone degenerative changes, and may possibly harbour a poison, pellagrosin, derived from a fungus, the *Reticularia ustilago* or *U. maidis*, whose spores are found under the maize husks.

Description.—The *Symptoms* are those of a tropho-neurotic disease, the alimentary, integumentary, and nervous systems being involved. There is gastric catarrh, an erythematous eruption followed by bullæ and ulceration or desquamation, pigmentation, and atrophy. Melancholia, alternating with mania, a kind of folie circulaire, sets in, along with twitchings, tremors, paralysis, cramps, and contractures. Extreme cachexia and dementia precede the fatal termination.

Differential Diagnosis.—Distinguish from dementia, general paralysis of the insane, leprosy, tabes, and Addison's disease.

Types.—Eruptive, non-eruptive.

Mortality.—Recovery is very rare, except in the initial stages.

Incidence.—*Age.*—Chiefly from 30 to 50, but children may be affected.

Sex.—Women are more liable than men.

Season.—The disease commences in the spring.

Method of Acquisition.—The ingestion of diseased maize.

Prevention.—Proper drying of the maize and provision of hygienic bakeries. Improved general conditions of the labouring classes in the localities where pellagra is endemic.

Establishment of asylums for cases whose home surroundings are poor.

Lathyrism.

Syn., Lupinosis.

Geographical Distribution.—Part of France, Italy, India. Kabylia.

Etiology.—The disease is due to a somewhat exclusive dietary on certain varieties of vetches, *Lathyrus sativus*, *L. cicera* (chick-pea).

Description.—The domestic animals sometimes suffer.

Symptoms.—They are apparently due to a slow sclerosis affecting the lumbar part of the cord, and appear in the form of a spastic paraplegia, with tremor, chiefly involving the lower limbs. There is a peculiar gait, exaggerated tendon reflexes and loss of skin reflexes, with hyperæsthesia and creeping sensations passing on to anæsthesia.

Differential Diagnosis.—Distinguish from Erb's syphilitic spinal paralysis.

Mortality.—It is not so high as in the two previous forms. There is a better chance of recovery if the disease is taken in time.

Method of Acquisition.—A dietary limited largely to the chick-pea.

Prevention.—Alter the diet. Remedy the adverse conditions of life.

Mushroom Poisoning.

Geographical Distribution.—It is more common on the Continent than in Britain.

Etiology.—It is due to eating poisonous fungi, for example, the *Agaricus muscarius* (fly agaric), in mistake for the edible *A. campestris*. The toxicity is due to muscarin and other similar bodies, such as choline.

Description.—*Symptoms.*—The onset is rapid, with vomiting, cramps, diarrhœa, and prostration, the result of severe cardiac depression. The pupils are contracted, and there is salivation.

Differential Diagnosis.—Distinguish from ptomaine poisoning from meat.

Mortality.—Recovery is the rule, owing to the emetic action of the poison.

Prevention.—Careful selection of mushrooms. Cooking does not obviate the danger.

B. CONTAMINATED FOODS.

The following metallic poisonings, descriptions of which have already been given, may occur.

Plumbism (p. 103).

From water, bread, confections, cider, wines, and spirits. Water may obtain lead in many ways, but chiefly from lead pipes and cisterns. Further, aerated waters may obtain lead from the action of carbonic acid on the metal used in their manufacture, from the silicate of lead which enters into the composition of glass bottles, and from bottles which have been scoured with lead shot and not thoroughly cleaned thereafter ; $\frac{1}{20}$ gr. per gallon constitutes a dangerous amount.

Bread has been known to become contaminated from the use of painted wood employed for heating the baking oven, and the filling up of holes in millstones with molten lead.

Confections may be dangerous from the use of colouring matters containing lead, and from contaminated sugar.

Cider may absorb lead from the storage casks or cider presses, and from leaden weights placed in the cider to prevent its turning sour. Wines may be contaminated in a similar way, while rum may absorb lead from the leaden worms of the stills.

Arsenicalism (p. 108).

From water, meat, and beer.

Arsenic may reach drinking-water from factory effluents.

Meat may become contaminated owing to the arsenic being given as a drug to animals. The presence of arsenic in beer is accounted for by the use of glucose as a substitute for malt, the glucose containing arsenic through having been prepared with impure sulphuric acid derived from iron pyrites containing arsenic. Another cause of contamination is the gas coke used in the preparation of the malt, as it often contains arsenic.

The *Symptoms* in the recent Manchester epidemic were indefinite skin eruptions, chiefly erythematous, pains in the soles of the feet and palms of the hands, herpes, conjunctivitis, vomiting, diarrhœa, paraesthesia, and peripheral neuritis with paralysis.

Prevention.—Recommendations of the Commission.

1. That the maltster be required to give a guarantee to the brewers that he does not employ gas coke in the preparation of his malt.

2. That the malt culms be regularly tested for the presence of arsenic.

3. If the culms are found to contain noticeable quantities of arsenic, that the kiln dust be at once removed, and the fuel employed be further examined for arsenic.

4. That, wherever possible, the best anthracite be employed for malting purposes. See also p. 246.

Antimonialism (p. 109).

From meat, owing to the use of antimony salts as drugs.

Cupralism (p. 108).

From tinned meats and vegetables, and from confections.

Zincalism (p. 108).

From tinned vegetables, the solder of the tin yielding zinc to the acid contents of the tin.

Gastro-Intestinal Derangements.

From meat, bread, milk, and confections. Thus meat may contain alum in irritating quantities, it having been injected as a preservative, while the skins of sausages stained with chromate of lead have been known to cause toxic symptoms. Meat may also contain alum, milk may be doctored with salicylic or boracic acid, or rendered hurtful through cows eating poisonous plants, such as Rhus toxicodendron, or suffering from mastitis or other diseases; while confections may prove harmful through their being coloured with hurtful dyes, such as chrome-yellow.

Nephritis

May occur in infants, owing to the regular ingestion of boracic acid in milk.

Abortion

Has been known to take place, owing to the genito-urinary irritation produced by the same milk preservative.

Nervous Symptoms,

Such as vertigo, delirium, hallucinations, and narcotism, have been induced by flour adulterated with *Lolium temulentum* or darnel seeds.

C. DISEASES DUE TO AN ILL-BALANCED DIETARY.

Gout, Hepatic Hypertrophy and Congestion.

From excess of proteids.

Fatty Degenerations, Obesity, and Glycosuria.

From excess of starches and fats.

Loss of Muscular and Mental Strength and Cachexia.

From deficiency of proteids.

Gastro-Intestinal Derangement and Wasting.

From deficiency of fat and starches. The former is the more important.

Scurvy.

Syn., Scorbutus.

From deficiency of fresh meat and vegetables.

Geographical Distribution.—There is land and sea scurvy, the disease being most common in sailors. It is, however, world-wide, and has to a slight extent affected our army in South Africa. It is endemic in parts of Russia, where it is looked on as an organismal disease.

Etiology.—Scurvy is possibly due to the want of fresh vegetables, which largely contain potash salts, such as the tartrates, citrates, acetates, malates, and lactates, which in the system are converted into carbonates. These carbonates assist in maintaining the alkalinity of the blood, and their deficiency is not compatible with a state of health. It must be noted that some do not regard the deficiency of salts as being a causal factor in the disease, and have suggested a microbal origin. A more probable view, and one supported now by experimental evidence as well as by the experience of recent arctic expeditions, is that scurvy is a chronic ptomaine poisoning due to the ingestion of tainted meat. Others think it possible that fresh foods, both animal and vegetable, contain some unknown antiscorbutic agent, the lack of which in the dietary induces scurvy. Overcrowding, cold, damp, mental depression and fatigue, all favour scurvy.

Description.—Symptoms.—Depressed health, pallor and lividity. Scurfy hair, spongy gums, skin eruptions and subcutaneous or even intramuscular hæmorrhages, giving rise to indurations and ulcerations. The petechiæ appear first on the legs, then on the arms and trunk, but are absent from the face. Fœtor of breath, dyspepsia, epistaxis and hemeralopia, are other frequent manifestations. The disease is slow and chronic, and, if unchecked, results in death.

Differential Diagnosis.—Distinguish from purpura, pernicious anæmia, splenic anæmia and leucocythæmia in isolated instances of the disease, and from peripheral neuritis and beri-beri in cases of epidemic prevalence.

Mortality.—At the present time it is trifling.

Incidence.—Age.—It is a disease of adult life, but there is a special form known as infantile scurvy, while the old are most susceptible.

Sex.—Males are more often affected, but this is accidental.

Climate.—Cold climates favour the disease more than warm, humid more than dry.

Race.—No race is exempt.

Prevention.—Avoidance of imperfectly preserved meat and wherever possible the use of fresh meat. Only the finest meat should be preserved, and the process should be most carefully conducted. An ample supply of fresh vegetable food, potatoes being especially valuable, and most green vegetables being useful. Peas and beans, rice and other cereals, are of little use. Fruits, such as grapes, raisins, and currants, which are added to American pemmican, are antiscorbutic. Desiccation, as a method of preserving fresh vegetables, renders them valueless as a cure for scurvy. Sauer-kraut is the best form of preserved vegetable.

In addition to fresh vegetables, fresh meat, particularly when raw or only slightly cooked, has beneficial properties, and the juice of the orange, lemon, or lime is an efficient antiscorbutic. Unboiled milk is useful, and acid wines are good. So are malt liquors, spruce beer, cider, and tea, which all contain much potash.

In the case of ships, short voyages are indicated, and the replenishment of the stock of fresh meat, fruit, and vegetables at every port visited. By order of the Board of Trade, no voyage is now undertaken without an ample supply of lime-juice and other antiscorbutics, and it is the custom to serve out 1 oz. of lime-juice per man per day. Scurvy is now rare at sea. In addition, vinegar, a valuable antiscorbutic, should be issued with the rations.

Prevention of overcrowding and other predisposing factors is necessary, preventive measures being specially required in time of sieges, campaigns, and agricultural distress.

Ponos.

Possibly ponos, an endemic disease of the Grecian Archipelago affecting young children, is closely allied to scurvy.

Rickets.

Geographical Distribution.—Prevalent in England, and in the large cities of all cold and damp countries.

Etiology.—Uncertain, but almost certainly due to faulty dietary in infant life, combined with want of sunlight and fresh air. It is probably connected with an excessive ingestion of carbohydrates coincident with a proteid-fat starvation and possibly with toxine formation in the intestine.

Description.—*Symptoms.*—Epiphyseal enlargement, excessive sweating, night restlessness, slight fever, and gastro-intestinal dyspepsia, leading to malnutrition, deformity, and stunted growth.

Incidence.—*Age.*—It is a disease of infants and young children, especially if weakly, prematurely born, or bottle fed.

Prevention.—Breast feeding during the first year of life, ample fresh air and sunlight, and proper clothing. A properly balanced dietary adapted to the digestive powers of the child during the early years of life.

Thirst, and various serious symptoms, such as failure of mental and muscular vigour, may arise from deficiency of water. The elimination of urinary constituents is much diminished, and the intestinal excreta are reduced in amount, as is the exhalation of carbonic acid.

Diseases which may be induced by drinking impure water—

General.	Specific.	Toxic.
Calculus.	Cholera, pp. 33, 179, 191.	Metallic poisonings as from—
Constipation.	Dysentery, pp. 41, 180, 191.	Arsenic.
Cretinism ?	Enteric fever, pp. 13, 181, 192.	Copper.
Diarrhœa.	Malaria, pp. 47, 181, 192.	Lead, p. 103.
Dyspepsia.	Parasitic diseases, p. 77.	Zinc.
Gastro-intestinal irritation.	Verruga ? p. 71.	
Goitre ?		

Calculus appears to be associated with the drinking of hard water, especially that derived from chalk and limestone regions. It is further dealt with in the consideration of soil (p. 178). A certain amount of constipation is often induced by a chalky water, but diarrhœa is a much more common result of the imbibition of water containing the chlorides, sulphates, and nitrates of calcium and magnesium. Water with much common salt dissolved in it has been known to produce diarrhœa, which may also be due to the presence of nitrogenous organic matter and various suspended substances, mineral, vegetable, and animal. Sulphuretted hydrogen waters also tend to produce looseness of the bowels. Permanently hard and chalybeate waters may give rise to dyspeptic symptoms, while water to which sewage has gained access has been known to cause symptoms resembling cholera, possibly owing to the presence of *B. enteritidis sporogenes*. The chemical composition of the drinking-water has in many cases been regarded as an etiological factor in the endemic prevalence of goitre. The water of goitrous regions is frequently derived from the magnesian and other limestones, and from strata containing serpentine; but other localities with a similar water supply remain free of the disease. Change of a water supply has been known to ameliorate the symptoms, and there can be little doubt but that water plays some part in the production of the disease, though its precise relation as a cause is unknown. The same remarks apply to cretinism.

GENERAL SANITATION.

METEOROLOGY.

Definition.—Meteorology is the science of atmospheric phenomena, their observation and interpretation.

These phenomena are temperature, sunshine, clouds, wind, moisture, rainfall, evaporation, pressure, electricity, and the presence or absence of ozone.

For their observation the instruments employed are thermometers, sunshine recorders, the camera, anemometers, hygrometers, and special thermometers, gauges, atmometers, barometers, electroscopes, and electrometers, ozonometers, and test papers. The observations are graphically recorded upon charts.

For their interpretation a certain knowledge of physical laws is requisite, and the results are recorded in weather forecasts. Meteorological observations taken in different localities, in order to be comparable, should be conducted with similar instruments, at similar periods of time, with similar exposure, and with a similar amount of care.

To be of any use, large numbers of observations are required, and this entails a somewhat tedious routine of work, and a recognition of the errors to which some of the instruments are liable.

Temperature.—The natural law that heat causes expansion is made use of for the purpose of estimating temperature, which is registered by thermometers. As the expansion of solids under the influence of heat is too small, and that of gases too great, liquids are employed in the construction of these instruments. Mercury and alcohol are the most commonly used, the former especially for high, and the latter for low temperatures. The advantages of mercury are its opacity, facilitating reading, its high boiling point, its low freezing point, its low specific heat (that is, it takes less heat to raise it through 1° C. than it would take to raise an equal weight of water 1° C.), its high thermal conductivity, and especially its quality of expanding to an equal extent at different temperatures for equal increments of heat. Alcohol is peculiarly serviceable at low temperatures, as it does not freeze till $-130°$ C. is reached.

A mercury thermometer consists of a closed glass tube with a capillary bore enlarged into a bulb at its lower end. This bulb contains the mercury. It is essential that the bore be uniform, that all air shall have been expelled, and that the thermometer after construction shall be kept some time before being graduated, to allow the glass to assume its final shape, since fused glass takes some time to return to its original density. Hence, were it graduated too soon, it might afterwards be found that the mark opposite zero was lower than the height at which the mercury stands when plunged into melting ice. This error is called the displacement of zero, and its result is to cause the thermometer to read too high. The graduation of every thermometer is done by direct experiment, in so far as the boiling point of water at standard pressure (760 mm. of mercury) and the melting point of ice are concerned. The height at which the mercury stands at these respective temperatures is marked on the stem as 212 and 32 if the Fahrenheit scale be employed, 100 and 0 if the Centigrade, and 80 and 0 if the Réaumur. Since water boils at different temperatures, according to the pressure to which it is subjected, and therefore according to the altitude at which it is placed, the standard boiling point to which the thermometer is graduated is the boiling point at sea level, with, as already stated, the barometer standing at 760 mm. or 30 in. of mercury. The point is ascertained by immersing the thermometer in steam given off by boiling water. For the freezing point the temperature of melting ice is preferred to that of freezing water, since water may, if perfectly still, be cooled below freezing point without freezing, although the least agitation will then cause it to become ice.

As Tennyson has it—

"Break thou deep vase of chilling tears
That grief hath shaken into frost."

The ice used must not contain salt, as this affects the freezing point.

These two points on the stem being fixed and marked, the interval between them is divided into a set of equal lengths, 180 in the case of F., 100 in C., and 80 in R. The relative lengths of each degree in these scales is therefore 9, 5, 4. Hence, to convert F. to C., subtract 32 from the F. reading, multiply the result by 5, and divide by 9.

Example.—To find the degree C. corresponding to 122° F., $122-32=90$. $90\times5\div9=50°$.

To convert F. to R., subtract 32, multiply the result by 4, and divide by 9.

Example.—To find the degree R. corresponding to 122° F., $122-32=90$. $90\times4\div9=40°$.

To change C. to F., multiply by 9 and divide by 5. Then add 32 to the result.

Example.—To find the degree F. corresponding to 75° C., $75\times9\div5=135$. $135+32=167°$.

To change C. to R., multiply by 4 and divide by 5.

Example.—To find the degree R. corresponding to 75° C., $75\times4\div5=60°$.

To turn R. into F., multiply by 9, divide by 4, and add 32.

Example.—To find the degree F. corresponding to 30° R., $30\times9\div4=67{\cdot}5$. $67{\cdot}5+32=99{\cdot}5°$.

To turn R. into C., multiply by 5 and divide by 4.

Example.—To find the degree C. corresponding to 30° R., $30\times5\div4=37{\cdot}5°$.

Supposing the F. reading is below freezing point, say 14°, what will this correspond to on the C. scale? Subtract 14 from 32, and 18 is obtained. Multiply this by 5 and divide by 9. This gives $-10°$ on the C. scale.

Supposing the F. reading is below zero, say $-20°$ F., what will this correspond to on the C. scale? In this case add 32 to -20. The result is -52. Multiply this by 5 and divide by 9. The answer is $-29°$ C.

$-40°$ C. corresponds to $-40°$ F. $-40\times9\div5=-72°$, and $-72+32=-40°$ F.

Varieties of thermometer used in meteorological work.

Standard thermometers are for observatory use, and are those with which other thermometers are compared. They are made with extreme care.

Ordinary.—These should be regularly tested for displacement of zero.

Maximum and minimum.—The maximum contains an ordinary mercury column, and is mounted horizontally. It records the highest temperature reached since last setting, by means of an index, which may be either a small

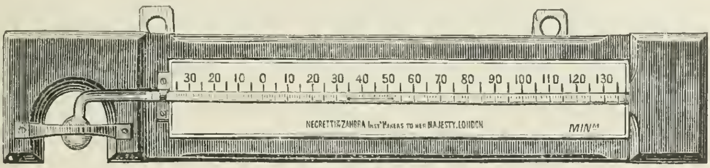


FIG. 46.

portion of mercury detached from the main column by a bubble of air, or consist of a little piece of glass, enamel, or metal, which can be pushed up by the mercury. In another form, a slight contraction of the glass tube fulfils the function of the bubble of air. They are reset by lowering the bulb, and by gentle agitation, or by bringing down the index to the mercury surface by means of a magnet.

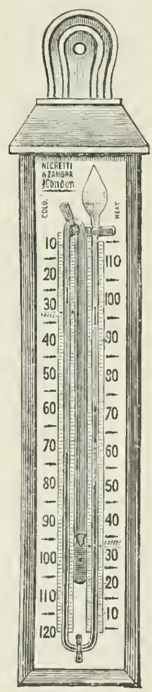


FIG. 47.

The minimum, which is also mounted horizontally (Fig. 46), may contain coloured alcohol or mercury, the latter being better for hot climates, as alcohol tends to volatilise. It records the lowest temperature reached since last setting; in alcohol by means of a metallic index immersed in the liquid, which can be drawn downward by the liquid, but which the liquid passes on its upward journey, *i.e.* as the temperature rises. The extremity of the index farthest from the bulb marks the lowest temperature reached. It is set by allowing the index to fall to the top of the spirit column. The mercurial form has no index, but possesses an accessory expansion, with a wide inlet below the graduated stem, into which the mercury, expanding on being heated, finds a more easy passage than into the indicating tube; while, on cooling, the mercury in the indicating tube flows back into the bulb or the expansion. The reading is made in the indicating tube, which thus records the lowest temperature reached, as the expansion prevents any subsequent movement of the mercury in the indicating tube.

Six's thermometer is a combined maximum and minimum containing both mercury and alcohol in a U-shaped tube, with each end surmounted by a bulb, the one wholly and the other partially filled with alcohol. The mercury fills the bend, and intervenes between two columns of alcohol. The indices are of steel, and are set with a magnet, and the temperature scale is marked opposite one limit from above downwards, and opposite the other from below upwards, the former registering cold, the latter heat (Fig. 47).

Shade thermometers ought to be so exposed that the air can circulate freely about them without coming into contact with any hot or cold surface, and they should be screened from the direct rays of the sun or any reflected heat. A Stevenson's screen is used to attain these objects. It is a roofed box with louvred sides and no bottom, and stands on legs 4 ft. above the ground.

Thermographs are thermometers connected with a style, which traces on a revolving cylinder the variations in temperature experienced.

Radiation thermometers are used for measuring heat radiation from the sun or the earth. Solar radiation instruments, which are maximum thermometers, have the bulb and lower end of the stem coated with lamp-black to prevent reflection from the glass of a large portion of the heat. The thermometer is enclosed in a glass case from which air has been extracted, and is elevated above the ground, and placed horizontally in an exposed situation, where it will not be shaded or subjected to reflected heat. The temperature is at the same time taken in the shade, and the two readings compared. Terrestrial radiation instruments, which are minimum thermometers, have bulbs of such a shape as to present a large surface. They are placed within a few inches of the ground, and their records are compared with that of the air minimum thermometer in the shade, the difference in the readings giving a measure of earth radiation. Radiation is much greater when the sky is clear.

In reading thermometers, if one daily observation be conducted, it should be made at 9 a.m., when the maximum thermometer gives the highest reading for the previous afternoon. The mean temperature of any day is not recorded by any instrument, but may be estimated by—(*a*) adding the maximum and minimum temperatures recorded in the shade, and dividing by 2; this method is good in winter, but in summer gives too high a reading: (*b*) taking the mean of two readings at twelve hour intervals, *i.e.* 9 a.m. and 9 p.m.: (*c*) taking a single reading at 8 or 9 p.m., or 8 a.m. in summer and 10 a.m. in winter; this is taken as the mean: (*d*) taking the mean of hourly readings, which may be conveniently recorded by photography.

As a rule, the highest daily temperature on land is attained at 2 p.m., and the lowest at 3 a.m. On sea the maximum is nearly one hour later. The diurnal variations of temperature are greater the higher the altitude and the farther removed from the sea. The hottest and coldest periods of the year do not coincide with, but occur later than, the summer and winter solstice. The presence of watery vapour in the air has an influence in diminishing the diurnal and nocturnal difference of temperature, owing to the heat absorbed and given out in its alternate evaporation and condensation, and to its effect as clouds in modifying solar and terrestrial radiation.

The factors determining the mean temperature of any given place are—(1) latitude; (2) altitude; (3) the ratio of land to water; (4) proximity to the sea; (5) vegetation; (6) aspect; (7) geology.

As regards latitude, the mean temperature diminishes from the equator to the poles from 82° F. to 2·5° F. As regards altitude, the mean temperature diminishes about 1° F. for every 300 ft. of ascent, or 1° C. for every 540 ft. The presence of much water and close proximity to the sea moderate the extremes of temperature, owing to the fact that water absorbs and radiates heat much more slowly than land. The sea is really the storehouse of the summer's heat, and its distributer during the winter months. Herbage radiates heat more rapidly than the bare ground, and thus tends to render hot climates cooler; while forests have the same effect, owing to their great evaporating surfaces, and the fact that they shield the soil. In the northern hemisphere a southerly aspect and in the southern hemisphere a northerly aspect are respectively the hottest. Clay soils are cold, while rocks and dry sand are hot, as they contain less water. The yearly range of temperature is not observable at a greater depth than 40 ft.

Isotherms are lines drawn on a chart through places having equal mean temperatures.

Fig. 48.

Sunshine. — Sunshine is made to automatically record its duration by means of a glass sphere (Fig. 48), so arranged as to focus the sun's rays on a sheet of cardboard or paper, along which they travel, scorching out their path. The cardboard or paper is divided up into sections corresponding to periods of time. Two sunshine recorders are the Campbell-Stokes' and the Whipple-Casella's, both acting on this principle. Another method is by employing photography to obtain a continuous record of the existence of sunlight, the impression being intensified during sunshine. Jordan's apparatus consists of two parts, one of which records the morning, the other the afternoon sunlight. A sheet of sensitive paper is enclosed in each semicylindrical box, through a central slit in the flat side of which the light enters and travels along the curved paper in a straight line. Like a sun-dial, the instrument must be firmly fixed and carefully adjusted, according to the latitude and longitude of the place (Fig. 49).

Fig. 49.

Clouds.—A cloud is a mass of aqueous vapour floating in the air at heights varying from a few hundred to many thousand feet. In different regions clouds are formed at different levels, in some at a great height, in others comparatively near the earth's surface. The lowest point at which clouds form, the cloud line, therefore varies in divers parts of the world.

Classification.—Clouds are named according to their appearance.

Cirrus.—White feathery clouds forming streaks or bands.

Cumulus.—Heavy looking, heaped-up accumulations with flat bases, domed summits, and irregular sides. These appear white or black according to their position in relation to the sun.

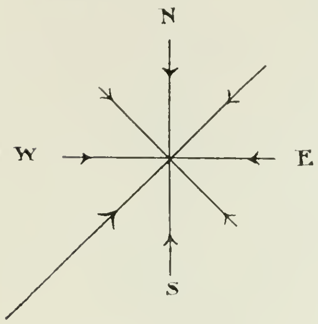


Fig. 50.—Wind-rose.

Stratus.—Horizontal stretches of fog and mist.

Nimbus.—Dark, threatening masses with ragged edges voiding rain or snow. There are various combinations of these four main types.

Clouds have an important effect in reducing radiation from the earth's surface and preventing such heat rays being lost in space. They also absorb much of the sun's heat, and protect the subjacent surface from solar radiation.

Winds.—*Direction.*—"The wind bloweth where it listeth," but this does not do away with the necessity of studying its movements. A "wind-rose" is a diagram of the points of the compass with lines drawn from a common centre and to scale, so as to represent the relative prevalence of the direction of the wind during a given time and at a given place (Fig. 50).

In this country a true north and south line stretches from N.N.E. to S.S.W. on the compass, so that a N.N.E. wind by compass observation is really a N. wind, and a S.S.W. wind really a S. wind. To obtain the true direction of the wind, an observer must be aware of the exact position of true N. and S.

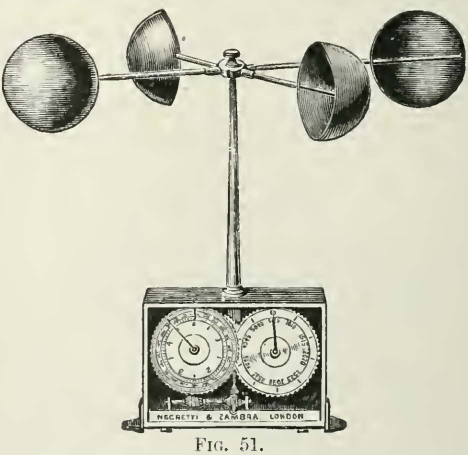


Fig. 51.

Pressure and Velocity.—These are measured by anemometers. Robinson's is the best for velocity, and consists of four arms, rotating horizontally round an axis, and each having at its extremity a hemispherical cup, on the concave surface of which the wind impinges with a greater pressure than on the convexity (Fig. 51). Consequently the arms revolve and register their revolutions on index dials, so many rotations of the cups indicating 1 mile of wind. The cups rotate with about one-half the velocity of the wind, owing largely to the effect of friction, which was formerly thought to be so great as to reduce the velocity of the cups to one-third that of the wind. An anemometer should be kept in good working order, well exposed, and placed 20 ft. above ground.

Other anemometers measure pressure, and have the advantage of registering the extra pressure experienced during gusts. The pressure may be estimated by means of the angle of displacement of a rectangular sheet of iron suspended by one edge at right angles to the wind, like an innkeeper's sign. In other forms of apparatus, displacement of the plate is resisted by weights or springs, and the force exerted is automatically registered. Another method is by allowing the wind to blow into the mouth of an open tube and impinge on the water or mercury of a manometer.

Pressure and velocity are convertible terms, the pressure varying with the square of the velocity, and being equal to $\frac{1}{200}$ of it, so that if V = the velocity in miles per hour, and P = the pressure in lbs. per square ft., $P = V^2 \times \cdot 005$ or $V^2 = 200\,P$. The pressure of wind may vary from that of a calm to a hurricane, and its force is denoted by a number from 0 to 12, varying with its velocity as shown in Beaufort's scale.

Scale.	Description of Wind.	Velocity in Miles per Hour.
0	Calm.	3
1	Light air.	8
2	Light breeze.	13
3	Gentle ,,	18
4	Moderate ,,	23
5	Fresh ,,	28
6	Strong ,,	34
7	Moderate gale.	40
8	Fresh ,,	48
9	Strong ,,	56
10	Whole ,,	65
11	Storm.	75
12	Hurricane.	90

In this country winds vary from 1 to 7 in the above scale; but over extensive land stretches, such as the United States and South Africa, it often attains to hurricane violence, doing great damage and causing loss of life.

Diurnal variations of the wind depend upon physiographical conditions. Wind commonly blows from sea towards land, or from plains towards hills, during the heat of the day. With the cool of the evening the direction is reversed. At the equator and over the open sea wind does not vary much diurnally.

Humidity or moisture in the air. Prior to discussing this question in full, it will be well to define certain terms used in connection with it.

1. *Saturation.*—Dry air can absorb a certain amount of moisture, this amount varying directly with the temperature of the air. The warmer the air the greater the amount of moisture it can absorb. The point of saturation is reached when the air has absorbed all the moisture it is capable of absorbing. Air may be saturated at each and every temperature. Saturation is expressed in terms of the pressure which the aqueous vapour present in the atmosphere exerts at the earth's surface, a pressure proportionate to its weight.

2. *Absolute humidity.*—This is the actual moisture in the air, and is expressed in the same terms as the saturation.

3. *Relative humidity* at any temperature is the moisture present in

the air, expressed as a percentage of the amount of moisture which would be present if the air were saturated at that temperature. The mere statement that air possesses a relative humidity of say 70 per cent., conveys no definite meaning as to the weight of water in the air unless the temperature be also stated.

4. *Defect of saturation.*—This is saturation minus the absolute humidity. It is the actual defect, not the relative deficiency, and therefore, without any need for stating temperature, it expresses the weight of water which would be required to raise the absolute humidity to saturation.

5. The *Dew-point* is the temperature at which the moisture present in the air, *i.e.* the absolute humidity, would suffice to saturate it. The point of saturation and the dew-point would correspond were the relative humidity 100 per cent.; when at any temperature the relative humidity is less than 100 per cent., the amount of moisture in the air would only suffice to saturate it at a lower temperature. This latter temperature is the dew-point. If the temperature of air containing a certain amount of moisture be lowered below the dew-point, the moisture is deposited in the form of dewdrops.

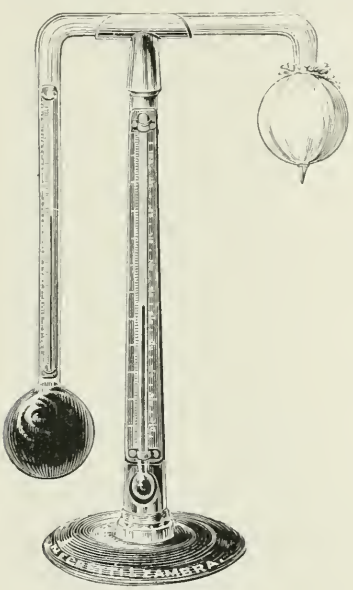


Fig. 52.

6. The *Drying power* of air is the capacity of the air to absorb more moisture than it already contains.

7. *Mist and fog.*—We have seen that pure water, if kept perfectly calm, may be cooled below freezing point without conversion into ice. If, however, it be agitated by having a number of stones thrown into it, it will at once congeal. In a somewhat similar way perfectly pure air saturated with moisture may be cooled below its dew-point without depositing dew. If, however, it contain particles of sand or dust, the moisture is at once deposited on those particles, giving rise to the appearance known as mist or fog, each particle acting as the nucleus of a water-drop. A dry fog is one where there is much dust and little moisture; a wet fog, where these conditions are reversed, producing a mist, a still further disproportion resulting in rain.

Hygrometers are the instruments used for determining the temperature of the dew-point. Some hygrometers disclose the dew-point by the actual deposition of dew upon a prepared surface; others provide data from which the dew-point can be calculated.

Daniell's hygrometer.—This consists of two glass bulbs connected by a bent glass tube supported on a stand. The lower bulb is blackened or gilded, the other is surrounded by a piece of muslin (Fig. 52). The black bulb, which is the larger, contains ether; and the smaller, ether vapour, all air having been excluded. A small thermometer is contained in the glass tube, and its bulb dips into the ether in the larger hygrometer bulb, while its stem can be read through the glass tube. An external thermometer is, for convenience of reading, fixed upon the stand. By means of ether evaporation, the temperature of the black bulb is lowered to the dew-point, moisture is deposited on it, and the temperature at which this occurs is read on the thermometer within the instrument, the temperature of the air under observation being registered by the stand thermometer. In performing the experiment, a little ether is poured over the muslin surrounding the smaller bulb. This evaporates, absorbs heat, and causes a condensation of the ether vapour in the small bulb, and an evaporation of the ether in the larger bulb. This lowers the temperature of the air surrounding the black bulb, and the process is continued till moisture is deposited on the outer surface of the black bulb. The temperature at which this takes place is the dew-point, but it is difficult to observe the precise moment of deposit; and, besides, the ether in the black bulb may not be at exactly the same temperature as the air round the

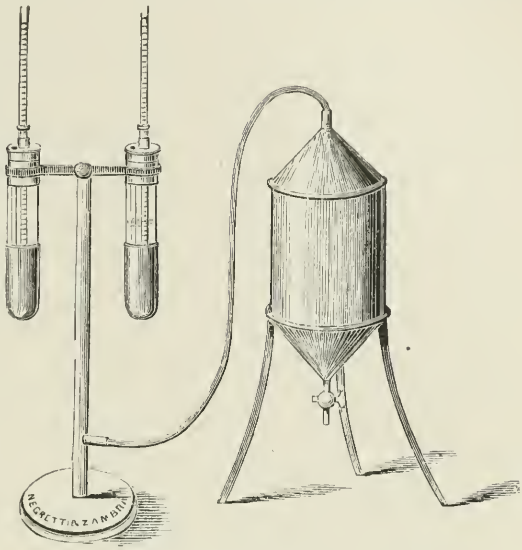


Fig. 53.—Regnault's hygrometer with aspirator.

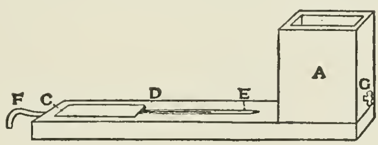


Fig. 54.—A, reservoir; G, tap; D, E, thermometer; C, black glass; F, overflow tube.

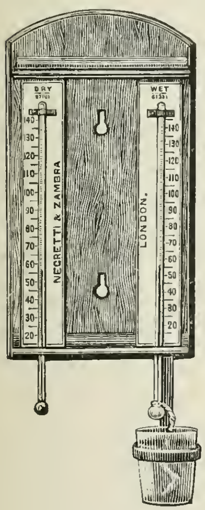


Fig. 55.

bulb. Consequently it is better to stop the process, observe the moment when the dew disappears from the bulb, and note the temperature. Then a mean of the temperature of deposit and of the temperature of the disappearance gives the true dew-point.

Regnault's hygrometer.—In this the dew-point is read off a thermometer, the bulb of which is immersed in ether contained in a corked silver receptacle. Evaporation of the ether is secured by pumping or aspirating air through it by means of an access tube reaching to the bottom of the ether, and an exit tube near the top of the receptacle (Fig. 53). The dew is deposited on the outer wall of the receptacle.

Dine's hygrometer.—In this a black glass plate, in contact with a thermometer and cooled down by running water, forms the surface for dew deposit (Fig. 54). In both these forms, as in Daniell's, the mean of the two readings is taken.

The wet and dry bulb thermometer or *psychrometer*.—This merely affords data for the calculation of the dew-point. It consists of two ordinary thermometers, one of which records the temperature of the air under observation (dry bulb), while the other has its bulb surrounded by a piece of muslin, kept constantly moist by the agency of a piece of grease-free cotton wick passing into a little vessel which contains water, and acting by capillarity (wet bulb) (Fig. 55). The wet bulb records a lower temperature than the dry bulb, owing to the evaporation. The dryer the air the quicker the evaporation, and the greater the difference between the two readings. In an atmosphere saturated with moisture, the two thermometers will record the same temperature. In case of freezing of the water, all that is required is to brush the surface of the muslin with a brush dipped in cold water, which in freezing undregoes evaporation. The wet bulb may read higher than the dry in thick fog or during still, cold weather. The dry bulb temperature is then taken as the dew-point. The formula for obtaining the dew-point from the recorded temperatures of the wet and dry bulb thermometer is as follows :—

$$DB - \{ (DB - WB) \times F \} = DP,$$

where DB = the dry bulb temperature, WB = the wet bulb temperature, DP = the dew-point, and F an empirical factor which varies with the temperature recorded by the dry bulb thermometer.

The factors for varying temperatures were calculated by Glaisher, and can be obtained from his table :—

GLAISHER'S FACTORS.

Reading of Dry Bulb Thermometer in F. degrees.	Factor.	Reading of Dry Bulb Thermometer in F. degrees.	Factor.	Reading of Dry Bulb Thermometer in F. degrees.	Factor.	Reading of Dry Bulb Thermometer in F. degrees.	Factor.
10	8·78	33	3·01	56	1·94	79	1·69
11	8·78	34	2·77	57	1·92	80	1·68
12	8·78	35	2·60	58	1·90	81	1·68
13	8·77	36	2·50	59	1·89	82	1·67
14	8·76	37	2·42	60	1·88	83	1·67
15	8·75	38	2·36	61	1·87	84	1·66
16	8·70	39	2·32	62	1·86	85	1·65
17	8·62	40	2·29	63	1·85	86	1·65
18	8·50	41	2·26	64	1·83	87	1·64
19	8·34	42	2·23	65	1·82	88	1·64
20	8·14	43	2·20	66	1·81	89	1·63
21	7·88	44	2·18	67	1·80	90	1·63
22	7·60	45	2·16	68	1·79	91	1·62
23	7·28	46	2·14	69	1·78	92	1·62
24	6·92	47	2·12	70	1·77	93	1·61
25	6·53	48	2·10	71	1·76	94	1·60
26	6·08	49	2·08	72	1·75	95	1·60
27	5·61	50	2·06	73	1·74	96	1·59
28	5·12	51	2·04	74	1·73	97	1·59
29	4·63	52	2·02	75	1·72	98	1·58
30	4·15	53	2·00	76	1·71	99	1·58
31	3·60	54	1·98	77	1·70	100	1·57
32	3·32	55	1·96	78	1·69		

Roughly, the dew-point temperature is as much below the wet bulb reading as that is below the dry bulb reading. Alternatively the dew-point can be calculated from the readings of the dry and wet bulb thermometer by Apjohn's formula. Note the elastic tension, in inches of mercury, of aqueous vapour at the temperature of the wet thermometer ($=f'$), the temperatures of the dry and the wet bulbs (t and t'), and the barometric pressure ($=p$). The elastic tension of the dew-point f'' is $=f' - \cdot 01147 \ (t-t') \ \frac{p-f'}{30}$; $\frac{p-f'}{30}$ may be neglected, and the formula worked out without it. The dew-point itself is then obtained from the table of tensions (see below).

Saturation.—A cubic foot of dry air can take up, so as to be saturated, a weight of watery vapour whose quantity varies with the temperature of the air. At freezing point this amounts to 2·13 grs., at 53° F. to 4·55 grs., and at 100° F. to 19·84 grs. The weight being known for each temperature, the absolute humidity can be calculated in grains per cubic ft. if the relative humidity be known. If air at 53° F. has a relative humidity of 70 per cent., the absolute humidity in grains per cubic ft. is equal to $4\cdot 55 \times \frac{7}{10} = 3\cdot 185$, and the drying power of the air is equal to $4\cdot 55 - 3\cdot 185 = 1\cdot 365$ grs. per cubic ft. A cubic foot of watery vapour exerts a force or tension at the earth's surface proportionate to its weight, and this, which is called the elastic force of vapour, is expressed in inches or mm. of mercury. To express inches as mm. × 25·4. The tension for each temperature is given in the subjoined table :—

Temp., F.	Tension in Inches of Mercury.	Temp., F.	Tension in Inches of Mercury.	Temp., F.	Tension in Inches of Mercury.	Temp., F.	Tension in Inches of Mercury.
0	0·044	24	0·129	48	0·335	72	0·785
1	0·046	25	0·135	49	0·348	73	0·812
2	0·048	26	0·141	50	0·361	74	0·840
3	0·050	27	0·147	51	0·374	75	0·868
4	0·052	28	0·153	52	0·388	76	0·897
5	0·054	29	0·160	53	0·403	77	0·927
6	0·057	30	0·167	54	0·418	78	0·958
7	0·060	31	0·174	55	0·433	79	0·990
8	0·062	32	0·181	56	0·449	80	1·023
9	0·065	33	0·188	57	0·465	81	1·057
10	0·068	34	0·196	58	0·482	82	1·092
11	0·071	35	0·204	59	0·500	83	1·128
12	0·074	36	0·212	60	0·518	84	1·165
13	0·078	37	0·220	61	0·537	85	1·203
14	0·082	38	0·229	62	0·556	86	1·242
15	0·086	39	0·238	63	0·576	87	1·282
16	0·090	40	0·247	64	0·596	88	1·323
17	0·094	41	0·257	65	0·617	89	1·366
18	0·098	42	0·267	66	0·639	90	1·410
19	0·103	43	0·277	67	0·661	91	1·455
20	0·108	44	0·288	68	0·684	92	1·501
21	0·113	45	0·299	69	0·708	93	1·548
22	0·118	46	0·311	70	0·733	94	1·596
23	0·123	47	0·323	71	0·759	95	1·646

The numbers given in this table represent saturation at each temperature, so that this is another method of expressing saturation.

Absolute humidity may be expressed either in grains per cubic ft. of moisture present, or in terms of the tension in inches or mm. of mercury exerted by the moisture in the air. The absolute humidity is greatest near the equator, least near the poles, greater on sea than on land, on the seashore than inland, in summer than in winter, by day than by night, at sea-level than at great elevations, and is also greater in the vicinity of water stretches.

Relative humidity.—This is equal to the absolute humidity $\times$ 100 and $\div$ saturation. $RH = \frac{AH}{S} \times 100$. It may be determined in two ways.

(*a*) By means of the wet and dry bulb thermometer. Note the dry bulb temperature, and refer to the tables for the tension of aqueous vapour, p. 135, which would be exerted at this temperature if the air were saturated. This figure will be the denominator in the above formula. From the wet and dry bulbs determine the dew-point, and refer to the table for the tension exerted by aqueous vapour at the dew-point. This figure is the numerator in the formula, and is the absolute humidity.

Example.—If the dry bulb temperature be 59° F. and the dew-point 41° F., what is the relative humidity?

$$\frac{\cdot257}{\cdot5} \times \frac{100}{1} = 51\cdot4 \text{ per cent.}$$

(*b*) *By Saussure's hygrometer.*—This consists of a human hair which has been rendered free from grease. It is fixed at one end, and connected at the other with a small weight. A lever is so arranged as to indicate any changes in the length of the hair, which, being hygroscopic, takes up moisture and elongates, afterwards contracting on again becoming dry. The lever thus records on a scale the percentage of relative humidity present. The scale is graduated by soaking the hair to saturation, and marking the point recorded by the lever as a hundred. The hair is then dried over sulphuric acid, and the point recorded by the lever is marked 15 per cent. of saturation, as it is impossible to wholly remove the moisture from the hair. The intervening space is graduated in equal parts. The relative humidity is high—

1. In the proximity of large, evaporating water surfaces.

2. In the absence of wind. Wind has a drying effect on the air, and thus lowers the relative humidity. This effect is most marked when the wind blows, as it frequently does, over extensive tracts of land. A wind which has crossed the Sahara will lower the relative humidity so much that the air becomes almost dry.

3. As a rule with an elevated temperature, but even at low temperatures it may be high. A high relative humidity at moderate temperatures, such as 50° to 60° F., is well borne by the human frame, since the cooling action of the vapour in the air removes heat by conduction and radiation, and thus relieves the sense of warmth and discomfort which would otherwise result, owing to the checking of evaporation from the skin, in consequence of the high relative humidity. At low temperatures a high relative humidity is unpleasant, as under this condition the humidity does not check evaporation to such a degree, and there is therefore excessive loss of heat by conduction and radiation. At high temperatures a high relative humidity is well-nigh insufferable, since the heat encourages strenuous attempts at evaporation, which are rendered futile by the high relative humidity; and, further, conduction and radiation do not suffice to relieve the heat.

4. At night as compared with day in this country, because the temperature during the night approaches the dew-point, and therefore there is an approach to saturation. A moisture, which during the day amounted to 70 per cent. of saturation, might during the night, with its colder temperature, reach saturation point.

5. In the morning, near the surface of the earth, owing to the evaporation of the dew by the rising sun.

Defect of saturation, stated in different words, is the difference between the amount of moisture in the air and the amount the air could hold were it saturated, the temperature remaining the same. It is measured in the same terms as saturation and absolute humidity, namely, as (*a*) the elastic tension of the aqueous vapour expressed in inches or mm. of mercury.

Example.—At a temperature of 59° F. and a dew-point of 41° F., the defect of saturation will be ·5 – ·257 = ·243.

(*b*) The weight in grains per cubic ft. of watery vapour.

Example.—With a temperature of 59° F. the weight of vapour required to saturate the air is 5·58 grs. per cubic ft.; while at 41° F., 2·97 grs. will suffice (see table). Thus the defect of saturation is 5·58 – 2·97 = 2·61 grs. per cubic ft.

Temp., F.	Weight in Grains of a Cubic Foot of Vapour.	Temp., F.	Weight in Grains of a Cubic Foot of Vapour.	Temp., F.	Weight in Grains of a Cubic Foot of Vapour.	Temp., F.	Weight in Grains of a Cubic Foot of Vapour.
0	0·55	26	1·68	51	4·24	76	9·69
1	0·57	27	1·75	52	4·39	77	9·99
2	0·59	28	1·82	53	4·55	78	10·31
3	0·62	29	1·89	54	4·71	79	10·64
4	0·65	30	1·97	55	4·87	80	10·98
5	0·68	31	2·05	56	5·04	81	11·32
6	0·71	32	2·13	57	5·21	82	11·67
7	0·74	33	2·21	58	5·39	83	12·03
8	0·77	34	2·30	59	5·58	84	12·40
9	0·80	35	2·39	60	5·77	85	12·78
10	0·84	36	2·48	61	5·97	86	13·17
11	0·88	37	2·57	62	6·17	87	13·57
12	0·92	38	2·66	63	6·38	88	13·98
13	0·96	39	2·76	64	6·59	89	14·41
14	1·00	40	2·86	65	6·81	90	14·85
15	1·04	41	2·97	66	7·04	91	15·29
16	1·09	42	3·08	67	7·27	92	15·74
17	1·14	43	3·20	68	7·51	93	16·21
18	1·19	44	3·32	69	7·76	94	16·69
19	1·24	45	3·44	70	8·01	95	17·18
20	1·30	46	3·56	71	8·27	96	17·68
21	1·36	47	3·69	72	8·54	97	18·20
22	1·42	48	3·82	73	8·82	98	18·73
23	1·48	49	3·96	74	9·10	99	19·28
24	1·54	50	4·10	75	9·39	100	19·84
25	1·61						

Drying Power of Air.—This depends on various conditions, such as temperature, wind, rains, etc., of which the most important is the temperature. We have already seen that air at a high temperature can take up per cubic ft. a much larger quantity of aqueous vapour than at a low temperature.

The drying power of an atmosphere with a relative humidity of 70 per cent. varies greatly with its temperature, since the weight of water required to saturate it at 80° is more than double that required at 40°. The amount of relative humidity alone is thus no guide to the drying power of the air. The temperature must always be stated. The defect of saturation, however, is a true measure of the drying power of the air.

Rainfall.—When air laden with moisture is suddenly cooled below its dew-point, the moisture is discharged as rain or snow. Moist air may be cooled by ascent to colder strata of the atmosphere, or by contact with the earth, more especially cold mountain ranges. Wind is a powerful factor in determining rainfall in any particular locality. A wind blowing from the sea to the land is generally wet, and vice versâ. Rainfall is estimated in inches of water; that is to say, if any given area were impervious, the rain falling on it would lie to a depth of so many inches, supposing no evaporation took place. The average annual rainfall in different parts of the world varies from a very few inches up to 50 ft. The heaviest rainfall occurs in the tropics and on high hills adjacent to wide oceans; the least in the deserts of continents. In the British islands the mean yearly fall is about 37 in., being greater on the west than on the east coast. The winter rainfall is greater than that of the summer. The daily rainfall in temperate climates rarely exceeds 1 in. No day is considered rainy unless it yields $\frac{1}{100}$ in. of rainfall. Rainfall maps show that there are seven well-marked bands of high and low rainfalls girdling the earth. These are the subequatorial wet belt, two subtropical dry belts, two temperate wet belts, and two polar dry caps. These belts move north and south with the sun. In equatorial regions there are two wet and two dry seasons every year. Most rain falls when the sun is highest, *i.e.* at noon, except on the west coasts of temperate lands (Herbertson).

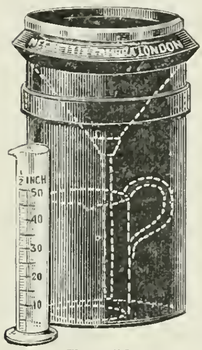


Fig. 56.

Measurement of rainfall.—For this purpose a rain gauge is used, which consists of a collecting surface and a measuring vessel. The collecting portion is circular in shape, and its area must be accurately known. It takes the form of a copper or tin cylinder, with its lip surmounted by a sharp-edged brass ring. The cylinder is continued downwards as a funnel, which communicates with a metallic receiving vessel, or with a graduated glass measure (Fig. 56). If the former be employed, it is necessary to measure separately the amount collected. The latter is apt to break, especially during frost. The rain gauge is best placed in the ground in an exposed position, with its rim a foot above the earth and clear from anything that could possibly shelter it. Snow or hail are estimated as rain by adding a known quantity of hot water sufficient to melt them, measuring the result and deducting the water added.

Calculation.—The diameter of the cylinder should be a definite number of inches, for example, 5 or 8, which are convenient figures. If it be 5, the collecting area will be $= 19{\cdot}635$ square in. (area of circle $= D^2 \times {\cdot}7854$). Suppose 1 in. of rain be collected in the receiving vessel. This means that 19·635 cubic in. of water have fallen on the area of the gauge. As a rule the diameter of the cylinder is 8 in., the area consequently being 50 square in. The glass measure for such a gauge is filled with 50 cubic in. of water, and marked at the level reached by the water. The part below this mark is then divided into 100 equal parts, so that each division represents ·01 in. of rainfall. There are other varieties, such as self-registering gauges, and gauges for storm rains and mountain work.

Evaporation.—Evaporation from a water surface depends on the temperature of the air, the humidity of the air, the wind, the barometric pressure, and the temperature of the water. It is greater the higher the temperature, the less the humidity, the higher the wind, the lower the pressure, and the greater the temperature of the water. It is greater in summer than in winter, and in spring than in autumn. It ceases when the air is saturated with moisture. Evaporation from a water surface may nearly equal, or in very dry years even exceed, the rainfall upon that surface.

Evaporation plays a great part in the distribution of atmospheric heat and moisture over the surface of the globe. The process of evaporation renders latent a very large amount of heat, which is again given out on the condensation of vapour into rain. By latent heat of vaporisation is meant the amount of heat required by water to change its physical condition into vapour without altering its temperature. On the reconversion of the vapour into water, this latent heat is set free. The first part of the process taking place chiefly within the tropical belt, and the vapour being transferred to colder northern climes, where it condenses, an interchange is established. The specific gravity of moist air is lower than that of dry air, consequently the former ascends, making room for drier air, which continues the evaporation. No good instrument for general use in estimating evaporation has been devised. Attempts are made to do so by atmometers, but the most simple method is to expose a known volume or weight of water in a shallow, open vessel, allow evaporation to proceed for a certain time, and note the difference in volume or weight, deducting from the volume or weight any rainfall which has occurred during the time of exposure.

Atmospheric Pressure signifies the effect of the weight of the superincumbent atmosphere. This pressure is produced by the combination of the pressures of dry air and watery vapour mixed in the atmosphere, and hence varies with the humidity. It is measured by means of a barometer, which may contain mercury, water, glycerine, sulphuric acid, or a vacuum. The mercury barometer in its simplest form consists of a glass tube at least 33 in. long, closed at one end, filled with mercury, and with its open end dipping into a trough of mercury. The pressure of the atmosphere on the surface of the mercury in the trough maintains a column of mercury in the tube at a height varying with the pressure. The tube is graduated in inches or mm., and the ordinary atmospheric pressure maintains the mercury at a level of 29·92 in. or 760 mm. The pressure on the upper surface of the column in the Torricellian vacuum is solely due to vapour of mercury, and may practically be neglected. The height of the barometer is the distance between the surface of the mercury in the trough and the surface of the mercury in the tube. Since the surface of the mercury in the trough, owing to variations in pressure, does not always exactly correspond with the zero line on the tube, a correction is required in using a barometer. This is attained in several ways.

1. In the *Kew barometer* the tube is graduated in nominal inches corresponding to the relative capacity of the trough and tube. The highest point on the scale is marked off correctly from a definite level in the trough. The

tube is then graduated from above downwards in inches, which are shorter than true inches in the proportion of the squares of the diameter of the tube and trough.

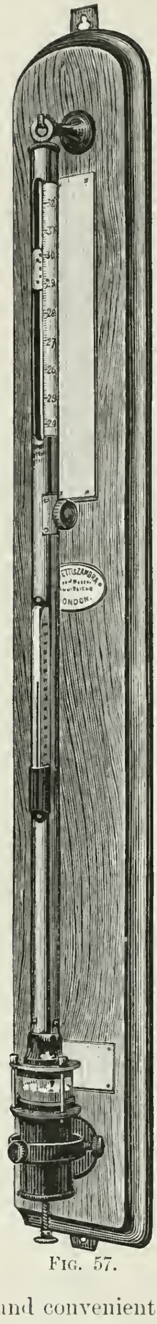


Fig. 57.

2. By *capacity correction.*—The scale is marked in true inches, and the maker records on the scale the ratio of the interior area of the tube to that of the trough, for example, $\frac{1}{40}$ or $\frac{1}{50}$; and further, marks a point at which, by experiment, the barometer has been found to read correctly. This is what is termed the neutral point, and when the level of the mercury is above or below this, the reading is too low or too high, and requires to be corrected by taking the indicated fractional part of the difference between the height read off and that of the neutral point and adding it to or subtracting it from the reading.

3. In the *Syphon barometer*, of which a common example is the wheel-bar, there is no trough at all. The mercury is contained in a U-shaped tube, the shorter limb of which is open at the end. The reading of the barometer is the difference of level in the two legs.

4. In the *Fortin standard barometer* (Fig. 57) the level of the mercury in the trough is adjusted to zero before each reading. Consequently the atmospheric pressure is correctly read off on an ordinary graduated tube. The adjustment is effected by providing the trough with a leather bottom and a screw, by which it can be raised till the mercury surface touches an ivory pin which marks zero. The upper part of the trough is made of glass, through which the contact can be observed.

Mercury as a barometric recorder is valuable on account of its high specific gravity, low freezing point, opacity, and the fact that its vapour does not readily tend to condense.

Water barometers.—The column of water required to balance the atmospheric pressure is 34 ft., consequently water barometers cannot be generally used, though very sensitive. Water is further unsuitable on account of its high freezing point and the liability of its vapour to condense.

Glycerine barometers.—The column necessary is 27 ft., and is very sensitive on account of its low specific gravity. Further, it has the advantage that it does not freeze, but, owing to its affinity for water, the surface of glycerine in the trough requires to be covered with a layer of paraffin oil.

Sulphuric acid has also been used as a recorder.

Aneroid barometers.—These are boxes with thin metal sides enclosing a vacuum. The atmospheric pressure forces in the sides of the box, and the finest movements of the metal work a lever which records them in an exaggerated manner. When the atmospheric pressure falls, the box regains its shape by means of a spring. They are sensitive and convenient, but apt to get out of order.

Reading of barometers.—For accurate reading two scales are required, a fixed or principal scale, and a movable, sliding scale or vernier (Fig. 58). The former is graduated in inches, tenths, and twentieths of an inch. The latter is graduated so that twenty-five of its divisions are equal to twenty-four of the smallest divisions of the fixed scale, that is, each division of the vernier is $\frac{1}{25}$ less than $\frac{1}{20}$ in., so that the vernier used in conjunction with the principal scale enables readings to be taken to ·002 in. ($\frac{1}{25}$ of $\frac{1}{20}$). The surface of mercury in a tube has a convex shape, due to surface tension, and the reading must be taken at the summit of the convexity. If this exactly corresponds with one of the divisions of the principal scale, its height is at once apparent. If it does not so correspond, read the highest mark on the principal scale which is lower than the surface of the mercury. Then slide the vernier along till its lower edge is just in a line with the summit of the mercury curve. In this position one of the vernier marks will exactly correspond with one on the fixed scale. Count the number of divisions on the vernier scale between this and the top of the mercury, and multiply ·002 in. by the number counted. Add the product to the reading already taken with the principal scale, and the result is the true reading.

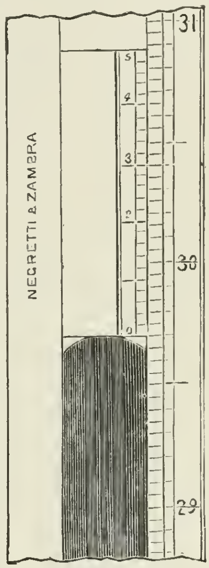


FIG. 58.

Precautions.—Barometers should be hung vertically in the shade, in a cool place, where they are not likely to be damaged. A thermometer should be attached to the case of each or placed near it.

Correction of barometers.—Barometers have to be corrected for—(1) capacity (already considered); (2) capillarity; (3) index error; (4) temperature; (5) height above sea-level. Capillarity tends to depress the column a little, and the error depends on the size of the bore, and on whether or no the mercury has been boiled in the tube in the process of expelling air from it. Index error is due to inaccuracies in the scale, and is corrected by comparison with a standard instrument. The first three, being incident to every barometer, are combined into a constant for each instrument. This constant correction for each $\frac{1}{2}$ in. reading is furnished by a Kew certificate. Temperature may affect not only the mercury itself, but also the material, usually brass, of which the scale is composed. Consequently, by general agreement, all barometric readings for purposes of comparison are reduced to what they would have been at a temperature of 32° F. or 0° C. The necessary correction for each height of the barometer is obtained from a table. Alternatively, since mercury expands $\frac{1}{9990}$ of its bulk for each 1° F., the correction can be applied for—(*a*) temperatures above 32° F., by subtracting from the inches of height of the barometer the result obtained by multiplying the number of degrees above 32° F. by the inches of height of the barometer, and dividing by 9990; (*b*) temperatures below 32° F., by adding to the inches of height of the barometer the result obtained by multiplying the number of degrees below 32° F. by the inches of height of the barometer, and dividing by 9990.

Height above sea-level.—Mercury falls in a barometer $\frac{1}{1000}$ in. for every foot of ascent, *i.e.* 1 in. for every 1000 ft., so that for places above sea-level there must be added to the reading $\frac{1}{1000}$ in. for every foot above sea-level.

The same must be deducted for places below sea-level. This fall in barometric pressure may be utilised as a means of estimating altitude. For this purpose the barometer may be read at the lower level and at the upper level to two places of decimals. Subtract the upper reading from the lower reading, and multiply the result by 900. This gives in feet the difference in height between the two levels. Owing to their portability, aneroid barometers are most convenient for this purpose. Since the higher the ascent the less weighty is the air, the number of feet of ascent necessary to cause a fall of 1 in. in the barometer increases the higher you go, 1000 ft. not sufficing at high altitudes. Therefore, when the reading of the barometer at the upper level is below 26 in., it is necessary to multiply by 1000 instead of 900.

Changes of Atmospheric Pressure. — Conditions favouring a low barometric pressure.

(1) Increase of atmospheric temperature, hot air being lighter than cold air; (2) humidity, moist air being lighter than dry air, because aqueous vapour mixed with dry air expands the volume of the air proportionately more than it increases its weight; (3) upward currents of air.

Conditions favouring a high barometric pressure.

(1) Decrease of atmospheric temperature, and consequent increase in the density of the air; (2) dryness; (3) compression of lower atmospheric strata by the pressure of wind at a higher level.

High barometric readings are therefore common in high latitudes, over continents, and in very cold countries. Low barometric readings are prevalent in the tropics and over oceans. Changes in barometric pressure may follow a regular sequence or be subject to irregular variations.

Diurnal and annual variations.—In this country diurnal variations are slight, but in tropical regions the range may be as great as ·1 in., the pressure being greatest morning and evening, and lowest in the afternoon and at night. Annual variations are more important. Their range is smaller near the equator than in high cold latitudes or in climates alternately hot and cold. In this country the barometer is usually highest in early summer, and lowest in early winter.

Irregular variations. — If observations of barometric pressure be made simultaneously at a large number of different places scattered over an extensive area, a chart can be drawn in which those places having the same barometric pressure are connected by lines. Such a chart is called a synoptic chart, and the lines are called *isobars.* Meteorological forecasts of weather are based upon such charts, in which the isobars are seen to assume certain definite shapes. Isobars commonly form circles or ellipses, in which the centre of the figure may be either the lowest or the highest pressure in the region. If the lowest pressure be at the centre, the system forms what is termed a *cyclone;* if at the periphery, an *anticyclone.* As contour lines indicate the differences in steepness of a hill slope, so the proximity to each other of the isobars of a system indicates the barometric gradient. The nearer the isobars the steeper the gradient. As contour lines are often drawn to show every 100 ft. of ascent, so isobars are frequently portrayed to exhibit differences in $\frac{1}{10}$ in. in atmospheric pressure. Barometric gradient may be stated as so many thousandths of an inch per 15 miles, or so many mm. in 1° of the meridian. The declivity of barometric gradient determines the velocity of wind.

Cyclones.—The area of low pressure constituting the centre of a cyclone does not remain stationary, but tends in the northern hemisphere to travel eastwards, owing to the rotation of the globe. The velocity of cyclones is about 20 miles an hour, and they are always accompanied by bad weather. The direction of their movement does not trace out a straight line, and they may be deflected, for example, by meeting high land or an anticyclone. Neither is their velocity constant. As the point of lowest pressure moves onwards, the barometric pressure at the place it is leaving rises, and the weather improves. Within the cyclonic system the wind blows with a force and velocity dependent on the barometric gradient, that is, on the sharpness of the differences in pressure rather than on the actual height of the barometric reading. Within a cyclone the wind blows towards the centre of the cup-shaped depression, but not directly, its motion being that of a spiral round the sloping sides of the depression. From the centre it blows vertically upwards out of the depression (Fig. 59). The wind currents in the cyclone are deflected by coming into contact with the earth's surface, so that the angle of the spiral current varies with the configuration of the land. In the northern hemisphere the wind current blows round the depression in a direction contrary to the movements of the hands of a watch ("anti-clockwise") (Fig. 60). Cyclones, though they may be very extensive, covering thousands of miles, have, as a rule, lesser areas than anticyclones. They tend to occur over oceans, anticyclones over land tracts.

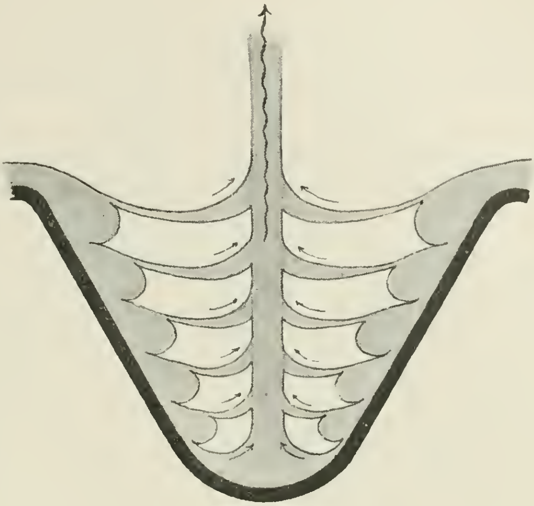


Fig. 59.

Fig. 60.

Anticyclones.—These areas with central high pressure tend to remain motionless and to cover extensive areas. They may be compared to inverted cup-shaped depressions (Fig. 61). At the centre the air is calm, since the wind blows out of an anticyclone, not into it, as in the case of a cyclone.

As in the cyclone the wind movement is spiral, but in direction it is "clockwise" in the northern hemisphere (Fig. 62). The deficiency caused by the

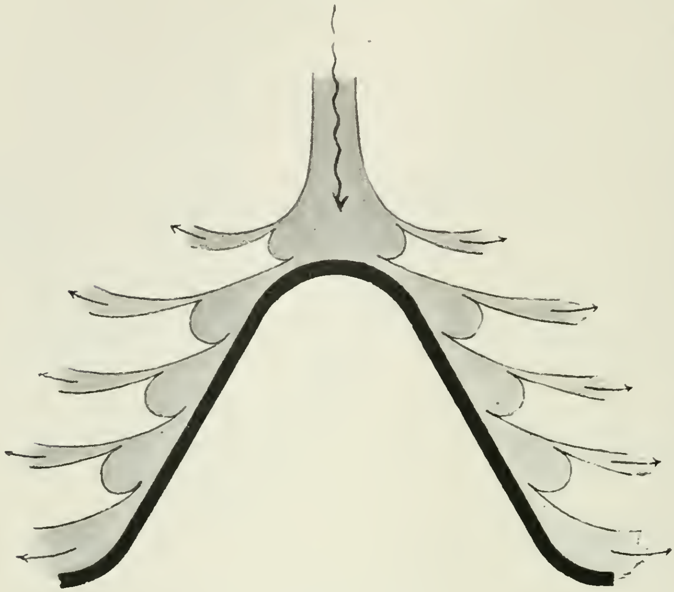


Fig. 61.

escape of wind from the borders of the anticyclone is remedied by the wind entering at the apex. Anticyclones are associated with fine weather conditions.

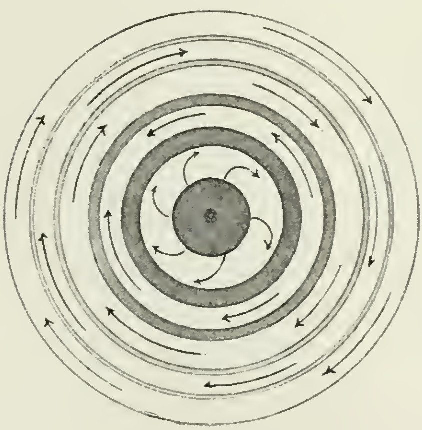


Fig. 62.

Whether the system be cyclonic or anticyclonic, an observer standing with his back to the wind always has lower pressure on his left, and higher pressure on his right hand. This is termed Buys Ballot's law. In studying a synoptic chart, in addition to the main isobar formation, there are other minor figures delineated. These are, secondary cyclones, V-shaped depressions, wedges, cols, and straight isobars.

Secondary Cyclones are incomplete cyclones, in which the isobars form only portions of a circle or oval. They are areas of low pressure, the lowest pressures, as in cyclones, being at the centre, while their movement also resembles that of cyclones.

V-shaped Depressions often form the angular interval between adjacent anticyclones, and often have their low pressure in the interior of the V. The tip of the V usually points south in the northern hemisphere, the depression moving eastwards. The weather associated with such a depression may be described as squally with shifting wind.

Wedges.—These are areas of high pressure found between adjacent cyclones, and with their apices usually pointing north.

Cols or necks of comparatively low pressure usually lie between two adjacent anticyclones. They are areas of calm and stagnant air, which may be the seat of thunderstorms.

Straight Isobars enclose no areas of low or high pressure, may run in any direction, and commonly occupy positions in which a cyclone is about to form.

Forecasts of weather depend on the distribution of isobars in a synoptic chart, and on the knowledge and experience of the forecaster as to the usual movements of cyclonic and anticyclonic systems within the area.

Notation of Charts.—A large number of abbreviation and special signs are used on those charts to denote various weather conditions.

Atmospheric Electricity.—Electricity in the atmosphere may vary in quantity and in quality, but is nearly always present. In fine weather the potential is usually positive, but during heavy rain it may be negative. On cloudy days the atmosphere between two clouds may be either positive or negative, according to the nature of the electricity prevailing in the clouds. There is commonly more electricity present in winter than in summer. Negative electricity in the air indicates rain, positive electricity fine weather. Electrical manifestations are thunder and lightning, hailstorms and aurora.

Thunderstorms are divided into cyclonic and heat storms, the former being low level, the latter often high level. Cyclonic thunderstorms accompany cyclones, and may occur in winter. They are apt to be dangerous, interchange of electricity taking place between clouds and the earth's surface. Heat thunderstorms accompany conditions of high temperature with sudden changes. In them the interchange for the most part is between cloud and cloud. Thunder itself is the audible accompaniment of the visible flash, and is due to rapid expansion of the air along the line of the flash, with a resulting inrush of air to fill up the vacuum produced by the passage of the flash. The rapid, rolling repetitions of thunder are due to echoes of the original sound from clouds or masses of air of different densities, and to variation in the distance through which portions of the original sound have travelled. Sound travels at the rate of 1100 ft. per second, so that five seconds elapse between the lightning flash and the thunder for every mile of distance between the storm and the observer.

Lightning is due to incandescence of the air produced along the path of the electric current, which generates intense heat, owing to the resistance of non-conductors in the air. In appearance it is sheet, forked, or globular.

Hailstorms are closely related to thunderstorms, hail being due to a conversion of water-drops to ice, where there is much moisture present in electrified clouds, and where the temperature falls below freezing-point.

Aurora.—The aurora borealis is the appearance presented when a positive electricity generated in the tropics reaches the upper regions of the atmosphere, passes through them, and, descending in the vicinity of the poles, encounters a negative earth electricity, the meeting producing a luminous discharge. Atmospheric electricity may be estimated in quality by the electroscope, and in force by the electrometer. It is produced—(1) when saline water is evaporating, the vapour being charged with positive electricity, and the water retaining negative electricity; (2) when alkaline water is evaporating, the action being similar; (3) when acid water is evaporating, the above process being reversed; (4) by evaporation of water from plants, and the respiratory interchange between the vegetable kingdom and the air; (5) by combustion, as in the discharge from volcanoes, positive electricity being set free; (6) by air movements producing friction owing to the effect of wind on suspended particles and water-drops in the atmosphere, and the contact of air currents with the surface of the earth, trees, buildings, etc.; (7) by the escape of electricity from apparatus harnessing it to the use of man.

Ozone, see p. 154.

CLIMATE.

Definition.—The word climate (κλιμα = a slope), which originally meant the lie of the land towards the sun, now signifies the sum of certain local conditions which influence the health of the inhabitants, and so render localities suitable or unsuitable for the growth and activity of mankind. Such conditions are air, temperature, moisture, sunshine, winds; the nature of the soil and the subsoil, and the cultivation of the former, the presence, absence, and character of vegetation, the elevation above sea-level, and the proximity or otherwise to the sea.

Classification.—1. Dependent on Temperature.	2. Dependent on Geography.
(*a*) *Hot or warm* { Equatorial. Tropical. Subtropical.	(*a*) *Ocean.*
	(*b*) *Continental.*
	(*c*) *Insular.*
(*b*) *Temperate.*	(*d*) *Mountain.*
(*c*) *Cold.*	(*e*) *Littoral.*

Hot or warm climates are found in regions within 35° of the equator, either north or south of that imaginary line. Their mean temperature may be as high as 80° to 84° F., but decreases with distance from the equator. They have a heavy rainfall, rarely less than 40 in. annually, and distinct dry and wet seasons.

Temperate climates are usually found in regions situated between 35° to 55° of latitude. Their mean temperature is about 60° F. They have a moderate rainfall, and possess four seasons in the year.

Cold climates occur in regions between 55° of latitude and the poles, and possess a mean temperature of from 5° to 40° F. They have little rain, but much snow, and possess two seasons, a very short summer and a very long winter.

Ocean climates signify those prevailing over great tracts of sea. The air is pure, moist, and frequently contains ozone. Winds are frequent; there is absence of shade, and a strong reflection of the sun from the water. The temperature variations are moderate, and the humidity is relatively constant.

Continental climates are such as exist over large expanses of land far from the sea, and not diversified by inland lakes. Here are found extremes of heat and cold.

Insular climates, owing to their proximity to the sea, are much more equable than continental climates, the temperature at different seasons of the year and at different times of the day varying within slight limits. Great Britain owes much of its comparative mildness to the influence of the Gulf Stream, which strikes its western shores.

Mountain climates, enjoyed by localities 3000 ft. and more above sea-level, are characterised by much sunlight, dryness, rarity, free movement, and coolness of the air, its freedom from suspended matters and micro-organisms, and the presence of ozone. There is a marked difference between the temperature of day and night, and a low barometric pressure. The rainfall largely depends on proximity to the sea, or rather, on the nature of the land between the mountainous region and the sea and the direction of the prevailing winds, whether blowing from the sea or otherwise.

Littoral climates, possessed in part by maritime countries, are characterised by equable temperatures, are moist, and have an atmosphere which may be described as bland and balmy. Weather changes are frequent, and otherwise they resemble insular and ocean climates.

Factors determining Climate.—These are *general* and *local*.

General.—Sunshine, temperature, humidity, atmospheric pressure, electricity, wind, rain.

Local.—The soil; the composition of the atmosphere as to purity and impurity; vegetation.

Influence of these Factors on Health.—*Direct* and *indirect*.

Sunshine.—Direct.—(*a*) *Excess.*—While a certain amount of sunshine is necessary for the perfect growth and activity of the human frame, exposure to a superabundance of sunshine may induce pathological changes, of which the chief is *insolation*. This may occur either in a mild or severe form. The mild form, which in England chiefly affects children, is characterised by headache, vertigo, prostration, pallor, and sometimes nausea and vomiting. The severe form of insolation which occurs in hot countries mainly affects the circulatory system, and may result fatally from syncope within a short time. The pulse is feeble, and the general cardiac depression may result in death, or, under proper treatment, may end in recovery, leaving no sequelæ. Minor effects of sunshine are seen in cutaneous inflammation, desquamation, pigmentation, and a general languor.

(*b*) *Deficiency* of sunlight, while perhaps compatible with moderate health, certainly detracts from exuberant vitality and the joy of living. It checks metabolism, leads to a stunting of growth, both bodily and mental, and favours the production of low forms of life.

Indirect.—The action of pathogenetic micro-organisms is favoured. Putrefaction is more easily induced, and proceeds more rapidly; and pollutions of air, soil, and water tend to be more gross, with therefore a greater liability to injure health. The direct rays of the sun in a dry atmosphere, however, tend to produce mummification with a concurrent cessation of organismal life.

Temperature.—Direct.—*Heat.*—The functions of the human body are best conducted within moderate limits of temperature. When it is subjected to excessive heat, a pathological condition allied to insolation, and termed *heat apoplexy*, is apt to occur.

Predisposing Causes.—Deficient ventilation, habit of body, overcrowding, fatigue, improper clothing, especially as regards protection of the head and spine, humidity of the atmosphere.

Incidence.—Numbers of people are attacked about the same time.

Natives of hot countries are not exempt, but Europeans not acclimatised are especially apt to suffer.

Symptoms.—They result from an effect on the cerebro-spinal system, and consist of nausea, giddiness, eye congestion, frequency of micturition, debility, coma, asphyxia, contracted pupils, quick pulse of low tension, pyrexia, and, it may be, hyperpyrexia. Coma with asphyxia or hyperpyrexia may end in death, which may be preceded by convulsions. Recovery, if it occur, may be followed by sequelæ, such as headache, chorea, epilepsy, and mental weakness. The minor effects of heat are shown by paresis of the digestive functions, excessive perspiration, diminished renal action, and languor of body and mind. Respiration is less frequent and less full.

Indirect.—These are the same as in the case of excessive sunshine, but are even more prejudicial to health, as, while the direct rays of the sun may actually inhibit the life and growth of some micro-organisms, a great heat in places not exposed to these direct rays encourages their vitality and multiplication. Further, heat stimulates insect activity, which gives rise to much discomfort, and, it may be, increased transmission of communicable disease.

Cold.—When acting directly for a short period, cold, even when very intense, has a bracing and tonic effect. If excessive in duration or intensity, it produces extreme languor, anæsthesia of mind and body, coma, and death from syncope and asphyxia. Less severe effects are seen on exposed parts in the occurrence of frost-bite and gangrene. Temporary exposure often causes pallor, cyanosis, shivering, increased micturition, and diminished respiration and perspiration. Indirectly, cold checks putrefaction and the activity of organismal life, thus exercising a beneficial effect. It tends, however, to more than counterbalance this by causing people to herd together for the sake of warmth, and by inducing them to avoid proper ventilation and cleanliness.

Changes of Temperature.—If rapid and unexpected, they may set up pathological conditions. Change from heat to cold often induces catarrhs and internal congestion; that from cold to heat is apt to cause diarrhœa and digestive disturbances.

Humidity.—In temperate climates life is best conducted when the relative humidity of the atmosphere is 75 per cent., that is to say, the air contains three-quarters of the moisture which it could possibly take up at the existing temperature. *Excessive humidity* is detrimental to health by checking evaporation from the skin and lungs, and thus permitting the retention of effete products. Indirectly it favours putrefactive processes, rank vegetation, and conditions under which low forms of life flourish.

Deficient humidity.—A dry atmosphere induces increased evaporation from the skin and lungs with retention of urea. There is dryness of skin and hair, and a tendency to cutaneous cracks and fissures. Indirectly, deficient humidity is beneficial to health, as it substitutes mummification of dead organic matter for putrefaction.

Atmospheric Pressure.—It is known that the human body can accommodate itself to pressure varying from 8 to 72 in. of mercury, that is, from 4 to 36 lb. per square in. Natural increase of atmospheric pressure is never so great as to occasion pathological conditions. The effects of excessive pressure have, however, been observed in the case of men working in diving-bells, caissons, and pneumatic chambers. They are lowering of the pulse, general torpor, headache, singing in the ears, and sometimes deafness; but there is speedy accommodation to the surroundings, and the real danger lies in suddenly changing from a high to a lower pressure. Then there may be severe epistaxis or hæmoptysis, paralysis, epigastric pain, neuralgia, etc. The effects of diminished atmospheric pressure are observable on climbing mountains or making balloon ascents. When an elevation of over 3000 ft. is obtained, there is quickened pulse and respiration, shallow breathing, increased evaporation from the skin and lungs, and a more concentrated urine. The weight of oxygen in a cubic foot of air is diminished in proportion to the diminution of pressure. This is compensated for by the quickened respirations. At great heights there is the so-called mountain sickness, characterised by nausea, vertigo, a feeling of weight in the limbs, and the occurrence of hæmorrhages, especially from the nose and ears. At 16,000 ft. the atmospheric pressure is reduced by one-half, being only $7\frac{1}{2}$ lb. per square in. Altitudes between 3000 and 6000 ft. act as veritable tonics.

Electricity.—An electrical state of the atmosphere frequently causes headache and a feeling of oppression, but the effects are largely modified by idiosyncrasy. When a thunder-cloud charged with electricity hangs over the earth, it induces an opposite electric condition in the subjacent earth, and possibly this induced state is also produced in individuals, and may account for the symptoms.

Winds.—These vary in their effects according to their velocity, and the temperature and humidity of the air. A cold wind, in proportion to its velocity, extracts heat from the body, while a hot wind withdraws little heat, but may increase the evaporation if the humidity of the air be not too high. As examples of dry winds prejudicial to comfort may be mentioned the *bise* of the Riviera and the *bora* of Trieste, bitter blusterers blowing from the Alps; the *mistral* of the Riviera, the *maestro* and the *tramontane* of Italy hailing from the same mountain chain, the *föhn* of Switzerland, the *brickfielder* of Sydney, the *spring east wind* of Edinburgh, the *harmattan*, *khamsin*, and *simoom*, winds of the desert. The well-known *sirocco*, a south-east wind, rises in the Sahara, absorbs moisture from the Mediterranean, and carries it to the Riviera, where it is moist. The *monsoons* are the summer and winter winds of India, and blow from the south-west and north-east respectively, the former being hot and moist, the latter cold and dry.

In this country the most prevalent winds are the west and south-west, which are usually warm and laden with moisture. The south-west wind is relaxing and enervating. The east and north-east winds most common in spring blow from the cold Russian plains and Norwegian glaciers, taking up some moisture from the German Ocean, but usually reaching Britain as dry, harsh, penetrating blasts, tending to cause catarrhs and internal congestions, and being very prejudicial to those suffering from phthisis, bronchitis, and rheumatism. Sometimes, however, they prevail in the form of an easterly "haar," bringing with it fine mist and small, chill rain. The dry east wind is bracing and invigorating for those strong enough to resist its forcible buffetings and keen persistence. North winds, though cold, are as a rule dry, save when they carry snow and hail.

Rain.—The chief effect of continued rain on health is its depressant action, while it forces people to stay under shelter and often prohibits adequate ventilation and exercise. In climates having much rain distributed throughout the year, rheumatism, certain forms of asthma, and other chest affections are common. The heavy rains occurring in tropical countries are often of the greatest benefit in "drowning out" epidemics and in purifying the soil. Rain washes the atmosphere, removing numberless impurities from the air of towns and cities. A rainy climate is not subject to great extremes of heat or cold, but it does not favour evaporation from the skin and lungs.

Local Factors.—The influence on climate produced by local conditions connected with soil and air are fully described in following sections.

Vegetation.—Trees and shrubs, if in excess, screen the soil from the sun's rays. It thus becomes chilly and damp in cold regions, and detrimental to health. In hot regions the ground is kept cool, and the great evaporation going on lowers the temperature of the air and helps to dry the soil, thereby producing a condition of things beneficial to health. Dense growth, however, checks air current, shuts off light, and leads to an insufferable closeness and gloom. It is to be noted that the lowest known type of mankind dwells in the dim twilight and stifling stagnation of the central African forest.

Vegetation attracts rain from clouds, and the extensive planting of forest or the excessive removal of growing timber greatly modifies the climate of a country. Extremes of heat and cold affect districts destitute of vegetation.

Climates in relation to Disease.—This may be considered under two headings—(1) The varieties of disease prevalent in different climates; (2) The varieties of disease modified by change of climate.

1. *The relative proportions of communicable and other diseases* differ very markedly in different climates. In warm climates the diseases which bulk most largely are communicable, such as malaria, dysentery, cholera, enteric fever, yellow fever, plague, leprosy, dengue, etc.; and, in addition, the climatic factors and habits of life depending on climate are such as to favour the transmission of parasitic disease, while insolation and heat apoplexy are naturally more frequent. Further, it would seem that certain diseases have the severity of their symptoms intensified under the conditions prevalent in warm climates, though racial peculiarities and sanitary defects, as well as climate, may account for this influence. This is true of hepatic disorders, malaria, cholera, enteric fever, and syphilis. The class of communicable disease prevalent in temperate climates is somewhat different from that which obtains in warm climates; in other words, the exanthemata are more prominent. In cold and temperate climates there is a tendency to an interference with the functions of the emunctories or a strain thrown upon them, hence lung and kidney diseases prevail, especially such diseases as croup, asthma, bronchitis, and Bright's disease. In these climates, also, exercise and labour are apt to be more severe and prolonged, hence possibly the greater frequency of cardiac and circulatory diseases. Phthisis occurs in most countries and most climates, but specially in climates where the changes of temperature are sudden rather than great in range, and where the air is humid and the soil is damp. It is rare in mountain climates. Some diseases seem little affected by the variation in mean temperature characterising different climates. Examples—pneumonia and cancer. In very cold countries, communicable diseases are rare.

As regards the geographical classification of climates, it is very difficult to apportion diseases amongst them, since so many other factors play a part, such as commerce, means of communication, water supply, and size of communities. A few facts may, however, be noted. In certain littoral climates pneumonia is rare, while malaria, dengue, and yellow fever flourish on low-lying sea-coasts. Mountain climates are, as a rule, inimical to pulmonary tubercle, but it is in high-lying valleys that goitre occurs.

Emphysema and cardiac affections are probably more abundant in elevated districts. The chief characteristic of ocean climates is the absence of disease.

2. *The therapeutic effects of change of climate* have been largely utilised in the treatment of disease. In the nervous strain produced by anxiety, over-work, grief, business worry, etc., a change of air and scene often assists return to health. In such cases an ocean climate is often beneficial, providing a bracing yet moderately temperate climate. In the treatment of phthisis, climate has in the past played a very important part. In early cases ocean and mountain climates have proved very valuable, but in recent years the extension of the open air treatment in home climates has produced such good effects, that recourse is likely to be had less often to the banishment and exile which a change of climate so frequently entails. Lung diseases, with the exception of early phthisis and some forms of asthma and catarrh, do best in a mild and moist climate. For cardiac diseases, a bracing, equable climate at a moderate height is best; and for many bowel complaints, a warm littoral climate, such as is met with on the north coast of Africa and in some parts of the Riviera, is suitable. Where the function of any emunctory is interfered with, the indication is to provide such a climate as will stimulate the other emunctories, and thus relieve the strain on the affected organs; hence part of the value of the West Indian and other warm and skin-stimulating climates in cases of Bright's disease.

Acclimatisation.—Fortunately for the human race, its individuals possess a power of adaptation to their environment which enables them to survive and reproduce their kind, notwithstanding climatic variations. It is now recognised that the native of a temperate climate can live as long and as healthy a life in warm regions as in his own country, provided his habits be, like his birthplace, temperate and his surroundings in every respect sanitary. In short, a clean soil, good air, pure water, and food and clothing proper in quantity and quality, are in warm, even more than in cold, countries the factors upon which his health will depend. Acclimatisation is in all cases a gradual process, and for a nation or race to become rapidly acclimatised to a new country is probably impossible; but if colonisation be conducted by a process of slow emigration, acclimatisation may be established even in a country possessing a climate widely divergent from that of the original home. Races vary in their powers of acclimatisation; thus, while Jews and Arabs have a wonderful facility of adaptation, Europeans can only become acclimatised with any speed in climates within the temperate zone. Further, races inhabiting temperate regions find it easier to colonise countries to the north of them. The influences preventing rapid acclimatisation in new isothermal regions are, according to Bertillon—(1) Acute diseases, many of them epidemic; (2) chronic consecutive anæmias diminishing the powers of resistance to acute disease; (3) prevalence of disease in early infancy amongst the offspring of the new-comers; (4) physical and intellectual degeneration and infertility of the second and third generations. An increase of fertility and vigour is sometimes seen amongst the colonists of a country peopled by slow emigration, provided the climate be not unfavourable, that the soil be moderately dry, healthy, and productive, and that the area of the country is sufficient to prevent overcrowding. This heightened virility rarely persists through more than a few generations.

AIR.

Composition.—Pure air possesses neither colour, taste, nor smell, and is composed of a mechanical mixture of various gases, in which is suspended a varying amount of organic and inorganic material. The gases composing the atmosphere are oxygen, nitrogen, carbonic acid, aqueous vapour, and small quantities of argon, xenon, krypton, metargon, and neon. In addition, ozone and ammonia may be present. The suspended matter may have vitality, such as living microbes, or be inanimate, such as dust particles, mineral matter, etc. The air maintains a tolerably uniform composition in all parts of the globe, owing to the diffusion of gases, variations of temperature, rain, air currents, and the equilibrium maintained by the respiration and transpiration of plants and animals. Anything which, by causing stagnation, interferes with the operation of these factors, produces conditions favouring an alteration in the composition of the air. In every 1000 parts of pure air there are 209·6 parts of oxygen, 790 parts of nitrogen and other gases, and ·4 parts of carbonic acid by volume. Expressed as percentages these figures become respectively 20·96, 79, and ·04.

Constituents.—*Oxygen* is the most important constituent of air, forming one-fifth of its bulk by volume, and somewhat more by weight. Oxygen confers upon the air those properties which make it a suitable medium for the persistence and activity of life. The quantity of oxygen in the air is increased actually by vegetation and relatively by rain. It is diminished by the respiration of man and animals, by combustion, by putrefactive processes, by many trades and manufactures, by the oxidation of organic effluvia, and at high altitudes.

Nitrogen forms the major part of the air, constituting nearly four-fifths by volume, and rather less by weight. Its function is to dilute the oxygen and to supply an element common to the tissues of animal and plant life. Its quantity is remarkably constant. It is probable that the amount of nitrogen in the air is somewhat less than has been generally believed, since it was estimated that the whole residue of gas in the air, after exclusion of oxygen and carbonic acid, was nitrogen. It is now known that air contains small quantities of other gases which were formerly regarded as nitrogen.

Carbonic acid, though only existing in small quantities in the air, is yet of extreme importance. It is produced in respiration, being given off in the expired air, and also wherever carbon is burned in the presence of oxygen. It may be evolved in the course of volcanic action, in the decomposition of organic matter, and in certain industrial pursuits. On the other hand, plants which contain chlorophyll absorb carbonic acid from the atmosphere, apply it to their own uses, and excrete oxygen, thus regulating the amount of these gases present in the atmosphere. This action takes place during sunlight, and is reversed during the hours of darkness; but on the whole distinctly more carbonic acid is absorbed than is given off. The ordinary proportion of carbonic acid in pure air is ·04 per cent., but if it rise to ·06 per cent., discomfort results, and a proportion of 1 to 1·5 per cent. produces toxic effects. Carbonic acid is also diminished in the atmosphere by rain and high winds, and is increased at very high altitudes, perhaps owing to the complete oxidation of organic matter. Interchange between the ground air and the atmospheric air may help to regulate the quantity of carbonic acid in the atmosphere, which shows regular seasonal and diurnal, as well as local, variations.

Seasonal variations.—In this country, and similarly in Buda Pesth, there is a spring and autumn rise, and a corresponding winter and summer fall, in the amount of carbonic acid in the atmosphere. The highest point is reached in the autumn. This seasonal variation has been explained in various ways, as the result of plant respiration, combustion, chemical interchange over large areas of sea, or transference between ground and atmospheric air. The spring rise at the time of greatest activity of plant life controverts the suggestion that vegetable respiration may be the cause, since it should rather tend to diminish carbonic acid. The autumn rise appears to dispose of the combustion theory, since it occurs at a time of year when fires have been least in use. It was supposed that in the presence of excess of carbonic acid in the atmosphere, carbonate of lime in sea water took up carbonic acid and became bicarbonate, and that the carbonic acid was again given off to the atmosphere when there was any deficiency. If this were the case, seasonal variations should be less rather than more pronounced. Of all the theories hitherto suggested, that of the soil air playing an important part gives the most probable explanation. Fodor found that carbonic acid in the ground air approaches its maximum when atmospheric carbonic acid is least, and that a fall in the carbonic acid in ground air occurs when atmospheric carbonic acid rises. It is probable that the soil is being ventilated in the autumn, and that the effect of rain in diminishing the carbonic acid in the air may be due to its sealing up the pores of the soil and preventing mingling of ground and atmospheric air. Fodor's Buda Pesth observations were confirmed by similar investigations in Edinburgh by Professor Hunter Stewart, who also showed that in laboratory experiments with soil there is probably an exit of carbonic acid from the soil when the temperature of the soil exceeds that of the atmosphere. Fodor further found that in the autumn the amount of carbonic acid in the air at soil level was greater than at 1 metre above the surface, but this was not confirmed in the Edinburgh observations.

Diurnal variations.—The Edinburgh experiments, continued over a long period of years, have shown that there are regular diurnal variations of the carbonic acid in the air, which differ in different seasons of the year. Thus there is more carbonic acid in the air in the morning and evening than at midday or midnight, and in spring there is more carbonic acid in the air in the morning than in the evening, while in autumn there is more carbonic acid in the air in the evening than in the morning. Diurnal variations are probably due to plant respiration as well as to admixture of atmospheric air with ground air.

Local variations.—Carbonic acid is less near the seashore than far inland, in the suburbs than in the centre of towns, in the country than in cities, and probably in some towns than in others.

Carbonic acid as an index of organic matter in the air.—While important in itself, carbonic acid is also important as an index of the quantity of organic matter in the air, since the two increase pari passu, and to the latter were attributed the ill effects of air vitiated by respiration. Of late years, however, these detrimental results have been ascribed to the carbonic acid in conjunction with the aqueous vapours and diminution in oxygen rather than to the organic matter.

Aqueous vapour.—This is a constant constituent of the air, but is by no means constant in amount, the quantity being largely dependent upon the temperature, and the facilities afforded for evaporation by the proximity of large areas of water. Average 9·6 per 1000 volumes.

The humidity of air and its effect on health have been discussed in the sections on Meteorology and Climate.

Argon, xenon, krypton, metargon, neon.—Rayleigh and Ramsay have recently discovered and named these gases, formerly undifferentiated from the nitrogen. They are of more interest to the physicist than the sanitarian, so far as their properties are at present known.

Ozone.—This is an allotropic form of oxygen, which may be represented by the formula O_3, 3 volumes of oxygen condensing into 2 of ozone, $3O_2 = 2O_3$. In this form the oxygen resembles nascent oxygen in its power of rapid oxidation, and in its exhilarating effects when inhaled. It never exceeds 1 part per 700,000 parts of air, and it is not possible to convert all the oxygen in the air into ozone. It is probably derived from the oxygen in the air by electrical currents generated in various ways, and is never present where there is organic matter which it can oxidise. It is frequently present in sea air, produced probably by frictional electricity due to the contact of wind and waves and air and water, or by evaporation of water in the presence of sunlight. It also occurs in air exposed to the aroma of pine forests, being perhaps generated by turpentines and camphoraceous essences. Ozone is absent from the atmosphere of towns, and is not found in air which has recently blown over towns or sewage farms.

Ammonia is present in the atmosphere in small quantities. Good air should not contain more than ·03 mgrms. per cubic metre (1000 litres). It constitutes one of the respiratory impurities, and is formed during putrefaction and decomposition. Ammonia may be present in the air either as free ammonia or in combination.

Suspended matter and micro-organisms.—The atmosphere always contains a certain amount of suspended matter, about 6 to 8 mgrms. per cubic metre, of which a large proportion is inorganic, consisting of particles of carbon, silicon, earthy salts, etc., and some organic, *i.e.* animal and vegetable filaments and bacteria. Dust particles alone have been estimated by Aitken to vary in number per cubic ft. from 2000 in the open country to 3,000,000 in towns, and 30,000,000 in inhabited rooms. The organisms are of the nature of moulds and yeasts, coccal forms and bacilli. The number of bacteria varies much in different places and under different meteorological conditions. Pure air contains in general about 750 micro-organisms per cubic metre. They are more numerous in the air of towns than in that of the country, and are extremely rare in the air over mid-ocean and deserts, and at high altitudes. They are increased in number during the spring, remain numerous during summer and autumn, then diminish and remain few throughout the winter. This is only true of the open air; in buildings, deficient ventilation having been found to exactly reverse these conditions. Rain has a greater effect upon them than temperature, and one which is purely mechanical, rains washing the atmosphere and transferring the microbes from the air to the soil. Consequently they are fewer in rainy seasons. Minute particles of watery vapour and of dust form resting-places in the atmosphere for the bacteria, which, when the air is quiet, tend to settle on adjacent solid matters from which they are speedily transported by currents and draughts. Desiccation and sunlight tend to diminish their numbers. The majority of the micro-organisms found in the air are non-pathogenetic saprophytes. Inoculation of animals with the dust of the atmosphere, or with cultures of dust organisms, gives negative results. The more vitiated the atmosphere the greater is the number of bacteria relatively to the number of moulds. The purer the air the more equal are their numbers.

Impurities.—The impurity of the atmosphere may consist in excess or deficiency of some of its normal constituents or the addition to it of abnormal constituents. Processes which vitiate the atmosphere in such a manner are—

(1) Respiration and transpiration of men and animals; (2) the exhalation, pollen, etc., from certain forms of vegetation; (3) the ventilation and disintegration of soil; (4) evaporation of polluted waters; (5) volcanic action; (6) putrefaction and decomposition of organic matter; (7) the employment of deleterious materials in buildings; (8) combustion; (9) trades and manufactures.

1. *The respiration and transpiration of men and animals* cause excess of certain normal constituents, namely, carbonic acid, watery vapour, and, to a slight extent, the ammonia and nitrogen. Oxygen is diminished. In addition, they increase the temperature and volume of the air, and contribute organic matter to it.

Composition of expired air by volume.

Oxygen	16·4 per cent.
Nitrogen	79·2 ,, ,,
CO_2	4·4 ,, ,,
Watery vapour	Variable.

Expired air thus differs from atmospheric air in containing a much smaller quantity of oxygen, a much greater quantity of carbonic acid and watery vapour, and a slightly increased amount of ammonia and nitrogen. Further, it gains in temperature and volume, and contains organic matter, the exact composition of which is unknown. Expired air in health has been shown to contain few if any micro-organisms. In respiration more oxygen is absorbed than there is carbonic acid given off, but the diminution of the volume of air so produced is more than compensated for by the increase in volume, owing to rise in temperature. At each respiration an average adult expires 22 cubic in. of air. If, therefore, he breathes eighteen times a minute, he gives off 23,760 cubic in. per hour. This contains, as stated, 4·4 per cent. CO_2, which is equivalent to ·6 cubic ft. per hour. Large men and those doing hard physical work give off more than this, and children and old people exhale less, but ·6 is a good average figure for a community. As might be expected, the amount excreted is less during sleep than during the working hours. The amount varies in different animals. Owing to the law of diffusion of gases, carbonic acid is spread uniformly through the air of any room in which it is given off, and is easily controlled by ventilation, thus differing from watery vapour and organic matter. The law of diffusion of gases states that gases diffuse inversely as the square roots of their densities, that is, the less dense the gas the greater is its power of diffusion. By transpiration is meant the excretion from the skin. Its effect in increasing the carbonic acid is infinitesimal compared with that of respiration. By its means, however, much watery vapour is added to the atmosphere, some ammonia and effete organic products. It yields some 20 oz. of watery vapour in the twenty-four hours, while respiration only accounts for 10 oz. Correlating this with the hourly exhalation of carbonic acid, these figures per hour become respectively 23·6 grms. and 11·8 grms. Such a large amount soon tends to saturate the air of a room with moisture, producing much discomfort. The organic matter in expired air is small in quantity, but it is nitrogenous, oxidisable, offensive, and readily absorbed by hygroscopic substances. Various materials and colours have a so-called selective capacity for organic matter, thus it is most readily taken up by wool, feathers, and moist surfaces, such as walls and papering, while straw and horse-hair have little affinity for it. Such peculiarities have their hygienic importance, and should influence the choice of bedding. As regards colours, the odour clings most persistently to black, a point which suggests that some revision is necessary in prevailing professional fashions, then to blue, yellow, and white, in the order mentioned. The close, musty odour of organic matter becomes perceptible when the amount of carbonic acid present is high, and is distinctly offensive when the carbonic acid amounts to ·1 per cent. The abnormal constituents which respiration may add to air are of extreme interest, owing to the possibility of communicable diseases being thus transmitted either through the agency of micro-organisms or as volatile poisons. Little is known regarding this, but it has been shown that special respiratory acts, such as coughing and sneezing, can expel microbes, for example, the tubercle bacillus, in the breath apart from the sputum. In addition to the products of respiration and transpiration, such gases as marsh gas and sulphuretted hydrogen given off by the intestines are added to the atmosphere. Cattle, for instance, expel a large quantity of marsh gas.

2. *Impurities from vegetation.*—All plants containing chlorophyll more or less vitiate the air during night by giving off carbonic acid, but they more than balance this action during the day by their absorption of carbonic acid and excretion of oxygen. Plants, however, should not be kept in bedrooms at night. In addition, special plants may foul the air by effluvia, for example, the *Rhus venenata*, but, like the sensation produced by the scents of certain flowers, their effects are largely influenced by idiosyncrasy, the myth of the Upas tree having been exploded. It is well known that the hairs of the Scots plane fruit, the pollen of various grasses, etc., can excite hay fever and asthma in those predisposed to such complaints.

3. *Impurities from the ventilation and disintegration of soil* may be gaseous or solid, the latter in the form of dust particles and bacteria. The interchange between the ground air and the atmosphere, with its bearings on the relative amount of carbonic acid in the atmosphere, has already been discussed. Since soil and its contained organisms act as purifiers of organic matter, it is probable that the ground air adds but little organic matter to the atmosphere. Ground air, however, is usually saturated with moisture, and therefore will increase the humidity of atmospheric air if mixed with it. The weathering of soil or its mechanical trituration, combined with the scouring action of winds, may diffuse particles of varying composition into the air as dust, and on such

particles bacteria may previously have obtained a lodgment. These particles, if mineral, may be of an irritating nature, as in the case of the gritty pulverised stone raised from macadamised roads. If organic, and derived from polluted soil, toxic effects may be produced by them.

4. *Evaporation from polluted water.*—The atmosphere may become vitiated by the upward currents of air induced during evaporation, carrying up with them micro-organisms and gaseous products, such as carburetted hydrogen, etc. Microbes are more readily given off if the evaporation be coincident with the bursting of bubbles on the surface of fermenting organic matter.

5. *Volcanic action* fouls the air by dust dissemination, and the fine dust may travel hundreds of miles, as was the case in the terrific disturbance which obliterated the island of Krakatoa from the surface of the sea. This dust is both mineral and vitreous, and the latter is the more widely dispersed. In addition, moisture in the form of immense quantities of steam, and gases, such as chlorine, fluorine, sulphurous and carbonic acids, emanate from craters and fissures. The air may also become charged with frictional electricity.

6. *Putrefaction and the decomposition of organic matter* diminish the oxygen and increase the carbonic acid in the atmosphere, and also add to it offensive organic vapours, and such gases as marsh gas, sulphuretted hydrogen, and ammonia, either free or combined. The air of marshes, in addition to these products of organic decomposition, contains much watery vapour. The air of cemeteries is similarly polluted with carbonic acid, organic vapours, and ammonia, while the air of vaults and opened graves may be very foul owing to such products. Sewer air and emanations from stagnant sewage lessen the oxygen, increase the carbonic acid and the organic matter, and may add sulphuretted hydrogen, marsh gas, ammonium sulphide, and carburetted hydrogen. The decay of organic matter increases the number of micro-organisms in the adjacent atmosphere, and undoubtedly produces ill health. The effect of such polluted air in lowering the vitality and increasing the susceptibility of individuals to disease, and especially infectious disease, has been amply proved. Such minor effects as headache, sore throat, nausea, anorexia, and anæmia are frequently manifested, and children suffer more than adults. Predisposition to diphtheria, scarlet fever, septicæmia, puerperal fever, enteric fever, and diarrhœa is also induced.

7. *Employment of deleterious materials in buildings.*—Concerning this method of vitiating the atmosphere, it is only necessary to refer to the once prevalent use of arsenic in wall papers and the resultant poisoning by vapour of arsenic and arsenical dust impregnating the air of rooms so papered. Dry and wet rot may also pollute the air so far as to cause ill health in the inmates of a building.

8. *Combustion.*—The combustion of coal and wood for heating purposes results in the removal of large quantities of oxygen from the air, and the discharge into the atmosphere of the products of combustion. In the case of coal, these are soot and tarry matters, carbon dioxide and monoxide, chlorine, bisulphide of carbon, sulphide of ammonia, and watery vapour, with larger or smaller amounts of sulphur, sulphurous, and sulphuric acids, according to the sulphur constituents of the coal, its quantity and extent of combustion. The large amount of coal used in manufacturing districts may result in as much as $\frac{1}{2}$ to 1 gr. of sulphuric acid being present in every 1000 cubic ft. of air, an amount sufficient to render rain-water acid in reaction. Wood also adds

carbon dioxide and monoxide to the atmosphere. Its other products differ from those of coal in the deficiency of sulphur compounds and the increase of watery vapour. Coke produces less smoke but more carbon monoxide than either coal or wood. The gaseous products of combustion are rapidly diffused in the atmosphere, but the suspended carbon and tarry matters, owing to their weight, hang over the neighbourhood of the place where they are produced. The term "Auld Reekie" was applied in the eighteenth century to Edinburgh by an inhabitant of Largo in Fife, who, on clear evenings, could see from across the Forth the haze of smoke forming a pall over the town at the time of the evening meal. He was wont to remark that "Auld Reekie was putting on her nightcap." This, however, is but a mild form of the evil as compared with what exists in manufacturing districts. As regards vitiation by artificial light, the burning of oil and candles adds organic matter to the air, besides carbonic acid and water. The combustion of coal-gas diminishes oxygen, increases carbonic acid and moisture, and produces other impurities very similar to those resulting from the ordinary combustion of coal. Each cubic ft. of coal-gas burned yields ·5 cubic ft. of carbonic acid, and ordinary gas-burners, such as the fish-tail and bat's wing, consume from 4 to 6 cubic ft. of coal-gas per hour. Good coal-gas should yield few sulphur compounds, as in its manufacture it is, to a large extent, purified from sulphur. Sulphur gases are very detrimental to the binding of books, leather upholstery, etc. Acetylene gas yields carbonic acid and watery vapour to the atmosphere, but is free from sulphur (see also p. 9).

Most *trades and manufactures* foul air by adding to it carbonic acid, heat, and moisture, and by removing oxygen. The other impurities produced vary with the trade. They may be—(*a*) solid; (*b*) liquid; (*c*) gaseous.

(*a*) *Solid.*—(1) Animal, such as hair from slaughter-houses, wool from textile factories, dried excreta from manure works; (2) vegetable, such as cotton and flax fibres from factories; (3) mineral, such as the dust produced in steel grinding, pottery making, stone cutting, file hammering, lead grinding, etc.

(*b*) *Liquid*, such as the moisture which condenses from the steam given off by many factories, workshops, laundries, etc.

(*c*) *Gaseous*, such as phosphorus fumes from match factories, arsenical fumes from copper works, mercurial fumes from ore smelting, lead fumes from ore smelting, zinc fumes from brassfounding, carbon monoxide from iron furnaces and water-gas, bisulphide of carbon from india-rubber works, sulphuretted hydrogen from chemical works, sulphuric and sulphurous acids from copper and bleach works, hydrochloric acid from alkali works, steel making, etc., and chlorine from chemical and bleach works and steel making. In addition, many kinds of organic vapours are generated which vitiate the atmosphere. As examples may be mentioned those produced in the trades legally defined as "offensive," and also in paper, brick, and cement making, distilling and brewing, refuse destruction, etc.

Weight of Air.—A cubic ft. of dry air at 0° C. and 760 mm. weighs 556·85 grs. A litre of dry air at 0° C. and 760° mm. weighs 1·293 grms. To compare the weight of any given volume of air with this, it is obvious that we require to know—(1) the volume in cubic feet or litres; (2) the humidity present; (3) the temperature; (4) the pressure.

The volumes being equal, dry air is heavier than moist air, cold air than hot air, and compressed air than free air, provided that in each case the other two factors remain constant. In this relation two great physical laws, those of Boyle and Charles, have to be considered.

Boyle's law states that the volume of a gas is inversely proportional to the pressure; in other words, the density of a gas is directly proportional to the pressure. The greater the pressure the less the volume. In calculating volumes, it is customary to estimate them at the standard pressure of 760 mm. A volume at a higher pressure than 760 will be increased when estimated at 760; thus 1000 c.c. at 780 mm. occupy 1026 c.c. at 760 mm. (760 : 780 :: 1000). Conversely, 1000 c.c. at 750 mm. occupy 986·8 c.c. at 760 mm. (760 : 750 :: 1000).

Charles' law is that, the pressure remaining constant, the volume of a gas expands, for every degree of rise in temperature, a certain fixed proportion of itself known as the coefficient of expansion. This coefficient has approximately the same value for all gases, being $\frac{1}{273}$ or ·003667 for each 1° C., and about $\frac{1}{492}$ or ·002036 for each 1° F. This coefficient holds good for all temperatures above what is called absolute zero, namely, −273° on the centigrade scale. Hence, $v = V + Vct$ or $v = V(1+ct)$ where v = the volume at t° C., V = the volume at 0° C., c = the coefficient of expansion, and t = the temperature.

Example.—A gas has a volume of 1000 c.c. at 0° C. What will its volume be at 21° C., the pressure remaining constant?

Substituting figures for letters, the equation reads—

$$v = 1000 + (1000 \times \frac{1}{273} \times \frac{21}{1}) \text{ or}$$
$$= 1000 + (1000 \times \frac{1}{13})$$
$$= 1000 + 77$$
$$= 1077 \text{ c.c.}$$

Since corrections have usually to be made for both temperature and pressure, the two laws are combined in a single formula—

$$V = \frac{v \times p}{760 \times (1+ct)}$$

where V = the volume required at 0° C. and 760 mm., v = the observed volume, p = the observed pressure under which the air exists, 760 = the pressure required in mm., c = the coefficient of expansion, and t = the temperature under which the air exists.

Example.—A volume of air at 21° C. and 750 mm. measures 1000 c.c. What will its volume be at 0° C. and 760 mm.?

$$V = \frac{1000 \times 750}{760 \times (1 + \frac{1}{273} \times 21)} = \frac{750{,}000}{760 \times (1 + \frac{1}{13})} = \frac{750{,}000}{760 \times \frac{14}{13}} = \frac{750{,}000}{818 \cdot 5}$$
$$= 916 \cdot 3 \text{ c.c.}$$

The equation is more easily worked out if ·003667 be substituted for $\frac{1}{273}$. For all ordinary purposes the combined law holds good for air. To ascertain the weight of a given quantity of air, it is necessary to remember the principles laid down by this combined law. Since the weight increases with the density of the air, it is by Boyle's law directly proportional to the pressure, and by Charles' law inversely proportional to the temperature. Hence, if we know that the weight of a litre of air at 0° C. and 760 mm. is 1·293 grms., we can calculate the weight of any volume of air at any temperature and any pressure thus—

$$W = \frac{1 \cdot 293 \times v \times p}{760 \times (1 + \cdot 003667 \times t)}.$$

It is essential to remember that in this case the volume must be stated in litres. Thus to convert cubic ft. into litres $\times 28 \cdot 2153$.

Example.—Find the weight in grms. of 50 cubic ft. of air at 21° C. and 750 mm.

$$W = \frac{1 \cdot 293 \times 50 \times 28 \cdot 2153 \times 750}{760 \times (1 + \cdot 003667 \times 21)}$$
$$= \frac{1368090}{818 \cdot 5}$$
$$= 1671 \cdot 46 \text{ grms.}$$

Hitherto we have been dealing with dry air, but the question of the effects of humidity upon the weight of air have to be considered. Moist air, as we have seen, weighs less than dry air. The calculation of its weight depends on the quantity of moisture present, the tension of aqueous vapour, the temperature, and the pressure.

Example.—Find the weight of 282 litres of air having a relative humidity of 75 per cent. at 21° C. and 760 mm.

$$W = \frac{1 \cdot 293 \times 282 \times 746}{760 \times (1 + \cdot 003667 \times 21)} = \frac{272011}{818 \cdot 5} = 332 \cdot 32 \text{ grms.}$$

The 746 is obtained by finding in the table of tensions of aqueous vapour (p. 135) the tension in inches of mercury corresponding to the F. temperature, *i.e.* 70°, which is equivalent to 21° C. This figure is ·733. Multiply this by 25·4 to convert it into mm. of mercury, and as the relative humidity is 75 per cent., take only three-fourths of the result. This is 14. Subtract this from 760, and the 746 is forthcoming. W = 332·32 grms. is the weight of 282 litres of dry air at 21° C. and under a pressure of 746 mm. The moisture has now to be weighed. Find from the table on p. 137 the weight in grs. per cubic ft. of aqueous vapour at 21° C. This is 8·01 grs. As the relative humidity is 75 per cent., three-fourths of this is taken, and it is converted into grms. by multiplying it by ·0648.

The result $8 \cdot 01 \times \cdot 75 \times \cdot 0648 = \cdot 389$ grms. = the weight of 1 cubic ft. As 282 litres = 10 cubic ft., multiply the above figure by 10. *Answer* = 3·89. This must now be added to the weight of dry air, *i.e.* 332·32. 332·32 + 3·89 = 336·21 grms. 282 litres of *dry* air at 21° C. and 760 mm. weigh 341·04 grms.

Examination of Air.—It is not intended here to fully discuss laboratory methods which do not come within the scope of this book, and must of necessity be mastered by practical work. All that is desired is to tabulate the rationale of the procedures used for determining the purity or impurity of air.

Preliminaries.—Note the temperature of the air and the barometric pressure. Be careful to take the sample when the air is under those conditions, the effects of which on its purity it is desired to test. Thus, in testing the air of a schoolroom, an erroneous impression would be formed were the sample taken in the early morning before any classes had met, or in the evening long after they had dispersed.

Collection.—The air is usually collected in large wide-mouthed glass bottles of a known capacity, being either pumped into them, allowed to diffuse into them naturally, or to enter them in place of distilled water which they have previously contained. The bottle must be quite dry when the test sample is taken, as carbonic acid is very soluble in water. Care must be taken that the sample be not contaminated by the expired air of those conducting the operation.

Physical test.—Note the smell. Air should always be examined in this particular immediately after the analyst has been in the open air, otherwise the olfactory sense may be blunted or perverted. An odour may be due to organic matter, coal-gas, sulphuretted hydrogen, bisulphide of carbon, acetylene, or other impurities which have gained access to the air. A smell due to organic matter is more perceptible when the humidity is high. Observe the floating dust revealed by a beam of sunlight.

Reaction.—Perfectly pure air is neutral, but in towns air may be either acid or alkaline from the presence in it of sulphurous acid or ammonia. Moistened litmus or turmeric papers are employed to test the reaction.

Oxygen.—The quantitative estimation of this gas may be made by—

(*a*) Combustion with excess of hydrogen.

(*b*) Absorption by pyrogallate of potash, the volume of air being measured before and after exposure to the pyrogallate.

(*c*) The nitric oxide method, which consists in mixing known volumes of air and nitric oxide. The nitric oxide and oxygen combine to form nitrogen dioxide, which is soluble in water, and thus the diminution in the combined volume of air and nitric oxide is an index of the amount of oxygen originally present in the air, one-third of the diminution being due to the oxygen which has been removed and dissolved as nitrogen dioxide. Equation, $2NO + O_2 = 2NO_2$.

All readings of gas volumes must be taken at the same temperature and pressure.

Ozone.—This is estimated by its powers of oxidation, various forms of test paper being employed.

(*a*) Papers dipped in a solution of potassium iodide. The ozone decomposes the potassium iodide, KOH is formed, and iodine is set free. The intensity of the brown colour of the iodine indicates the amount of ozone present.

(*b*) Papers dipped in a solution of potassium iodide and starch. Here the liberated iodine strikes blue (iodide of starch) with the starch.

These two methods are uncertain owing to the colour not being permanent, a long exposure causing the formation of iodate of potash. Another objection is that an atmosphere containing nitrous acid or peroxide of hydrogen would, like ozone, liberate iodine; and a third is that light, wind, temperature, and moisture vary, and all affect the reaction. When done quantitatively, the colour produced is compared with a scale of standard tints.

(*c*) Papers soaked in wine-red acid litmus and then dipped a portion of their length in a solution of iodide of potash. The KOH liberated turns the litmus permanently blue. Better than test papers is the method of aspirating air containing ozone through a solution of arsenite of sodium and potassium iodide. The ozone is reduced to oxygen $2O_3 = 2O_2 + O_2$, and the oxygen converts the arsenite into arseniate, the potassium iodide aiding the chemical action, $As_2O_3 + O_2 = As_2O_5$. The amount of arsenite remaining indicates the amount of ozone which was present.

Carbonic acid may be estimated by *Pettenkofer's method.* The rationale of this test is that lime or baryta water will absorb CO_2 from the air, and be thereby diminished in alkalinity. The amount of CO_2 is estimated from this diminution by means of a standard solution of crystallised oxalic acid. Baryta combines with CO_2 to form barium carbonate, $BaCO_3$, and with oxalic acid to form oxalate of barium, BaC_2O_4.

$$BaO + CO_2 = BaCO_3$$
$$BaO + C_2H_2O_4 = BaC_2O_4 + H_2O.$$

This shows that CO_2 and oxalic acid have the same combining power with baryta, and thus the one can be taken to readily estimate the other. 126 is the atomic weight of crystallised oxalic acid. 44 is the atomic weight of CO_2, and 44 grms. corresponds to a volume of 22·33 litres. Therefore 126 grms. oxalic acid are equivalent to 22·33 litres CO_2 in power of combining with baryta. $\frac{126}{22 \cdot 33} = 5 \cdot 64$, and thus 5·64 grms. oxalic acid is equivalent to 1 litre CO_2.

Hence if 5·64 grms. oxalic acid be dissolved in 1 litre of water, a solution results of which 1 c.c. = 1 c.c. CO_2 at 0° C. and 760 mm.

In practice a solution one-quarter this strength is employed, namely, 1·41 grms. to the litre, 1 c.c. being equal to ·25 c.c. CO_2. 25 c.c. of the saturated solution of baryta about to be used is titrated with this oxalic acid solution to determine its precise alkalinity, which is carefully noted. Phenol-phthalein is used as the indicator, because it gives a red colour in alkaline solution, which vanishes the moment such a solution becomes acid. The sample of air is shaken up with 100 c.c. of the same baryta solution, and after the barium carbonate formed has settled, three quantities of 25 c.c. each are titrated with the oxalic acid solution. These smaller quantities are employed —(1) to correspond with the baryta titrated; (2) so that, to insure accuracy, the same result may be twice obtained; (3) because the whole 100 c.c. cannot be collected owing to the precipitated barium carbonate. The altered alkalinity of the 25 c.c. of the baryta solution is determined and compared with its original alkalinity, the difference indicating the amount of the oxalic acid, which is the equivalent of the CO_2 that has gone some way in neutralising the baryta. Every c.c. of difference so obtained corresponds to ·25 c.c. of CO_2. Since, however, the figures only refer to 25 c.c. of the 100 c.c. used, it follows that each c.c. of difference corresponds not to ·25 c.c., but to 1 c.c. CO_2 in the whole 100 c.c. of baryta solution. If lime be used, the corresponding equation is $CaO + CO_2 = CaCO_3$.

Since the CO_2 is estimated in volumes corresponding to weight, no correction of the volume of CO_2 for temperature or pressure is required. Unless, however, the air sample be taken at 0° C. and 760 mm., its volume must be corrected to this standard. Further, a deduction must be made for the air displaced by the 100 c.c. of baryta solution or lime solution added to the bottle. The process may be conducted in another but less satisfactory manner, which consists in using 60 instead of 100 c.c. and an oxalic acid solution of 2·25 grms. per litre, each c.c. of oxalic solution corresponding to ·4 c.c. of a solution of CO_2, as, in the case of lime, shown by the equation—

$$CaO + CO_2 = CaCO_3$$
$$56 + 44 = 100.$$

Hence 1 mgrm. of lime neutralises $\frac{44}{56}$ mgrm. CO_2. Then 44 mgrms. being equal to 22·33 c.c., each mgrm. of lime is equal to about $\frac{22·33}{56}$ or ·4 c.c. of CO_2 or to 1 c.c. of the oxalic solution. For examining the CO_2 the air may be collected in a bottle after the usual fashion, and the barium or lime solution thereafter added to it, or the air may be slowly aspirated through special glass tubes containing the necessary solution which absorbs the CO_2 en route.

Angus Smith's "minimetric" method is easy and simple, but not so exact as Pettenkofer's. It is based on the determination of the amount of air required to produce cloudiness in a given volume of lime water, the CO_2 in the air combining with the lime to form $CaCO_3$. It can be done in separate bottles of varying sizes by merely shaking up the contained half ounce of lime water with the contained air. If a cloud be obtained with this amount of lime water in a bottle with a capacity of 100 c.c., the CO_2 in the air amounts to 2 parts per 1000. If in a bottle of 200 c.c. capacity, to ·9 parts per 1000, and if in a bottle of 300 c.c. capacity, to ·6 parts per 1000.

Another way is by blowing air from a rubber bag through a single glass vessel containing a definite quantity of lime water, and noting the number of compressions given to the rubber bag before an opacity is produced sufficient to obscure a black cross traced on a paper attached to the opposite side of the vessel. Anything less than 15 compressions of the bag corresponds to more than ·6 parts per 1000 of CO_2.

Nitrogen.—The residue left when the oxygen has been absorbed by pyrogallate of potash is considered as the nitrogen present, though some is no doubt due to those newly-discovered gaseous constituents of air, argon, etc. Argon is believed to form 1 per cent. of the total nitrogen.

Watery vapour.—The method of determining the amount of moisture in the air has been discussed under Meteorology (p. 132).

Ammonia may be collected by aspirating air through distilled water or 5 per cent. HCl. Its presence and, if necessary, its exact quantity is then determined by Nessler's method (*vide* p. 196). If HCl be used, the ammonia which it contains must first of all be estimated, and its amount deducted from that found in the acid after the passage of the air through it. A rapid qualitative test is to expose strips of filter paper moistened with Nessler's solution. These are turned yellow by ammonia. An ethereal solution of the alcoholic extract of logwood may be used instead of the saturated solution of mercuric iodide in potassium iodide (Nessler's solution). The logwood becomes purple.

Organic matter.—This is estimated either in terms of the oxygen required to oxidise it, or in terms of the free or albuminoid ammonia yielded by it.

1. *In terms of the oxygen supplied.*—A known volume of air is drawn through or shaken up with a solution of potassium permanganate of known strength, the colour of which becomes altered owing to its oxidising the organic matter. The amount of undecomposed permanganate remaining may

be determined—(*a*) by titration with oxalic acid or sodium thiosulphate, the operation being complete when all the colour vanishes, or (*b*) by the addition of fresh permanganate till the original colour returns. This latter method is not good if the air be very foul. For the organic matter alone permanganate does not form an accurate test, since other oxidisable matters besides those of an organic nature may be present.

2. *In terms of free and albuminoid ammonia.*—The sample of air to be examined may be collected by aspiration of a known volume of air through distilled water, weak HCl, or powdered pumice-stone, or by condensing the watery vapour in the air by passing the air through a tube surrounded by a freezing mixture. The condensing vapour washes most of the organic matter out of the air, and the rest is obtained by leading the air through distilled water. The organic matter collected in any of these ways is determined as free ammonia by distillation and Nesslerising of the distillate, and as albuminoid ammonia by Wanklyn's process (p. 197). The ammonia which is estimated as free ammonia is that which is present per se or in such combinations as yield ammonia on heat—for example, urea. The ammonia which is estimated as albuminoid ammonia, is that which is derived from more stable combinations, such as those with organic acids and from nitrogenous organic matter. It requires for liberation the addition of heat along with alkaline permanganate of potash.

Qualitative tests.—Organic matter renders pure water offensive to smell and taste, decolorises permanganate of potash, blackens when ignited on platinum, and is precipitated from solution by silver nitrate.

Carbon monoxide.—The amount of this gas present is determined by first of all removing the oxygen in the air, and then passing the remainder of the air into an acid solution of cuprous chloride. This absorbs the CO, and the loss in volume gives the quantity.

Qualitative tests.—This depends on the spectrum of oxyhæmoglobin obtained by mixing the sample of air with a little pure water and a drop or two of blood, and examining it spectroscopically. If CO be present, the spectrum remains unchanged when ammonium sulphide is added to the sample, but if there be no CO the ammonium sulphide reduces the hæmoglobin and alters the spectrum. In the presence of this gas, palladium potassium chloride is turned black. Both chloride of copper and chloride of gold are precipitated from their solutions by carbon monoxide.

Sulphurous acid in air is estimated by mixing a known quantity of air with a solution of iodine, and estimating the amount of iodine converted by the SO_2 into iodide of hydrogen. The strength of the iodine solution is obtained by titration with sodium thiosulphate.

Equations.

1. $SO_2 + I_2 + 2\ H_2O = H_2SO_4 + 2\ HI.$
2. $2\ Na_2S_2O_3 + I_2 = Na_2S_4O_6 + 2\ NaI.$

Qualitative test.—A paper spotted with bichromate of potash is changed from yellow to green.

Sulphuretted hydrogen.—Its quantity is estimated in the same way as SO_2, since iodine decomposes H_2S, setting free sulphur, which is oxidised. A qualitative test for H_2S consists in noting the formation of black sulphide of lead, when strips of filter paper, which have been dipped in a solution of lead acetate, are exposed to the action of the gas. It also alters a bichromate-spotted paper from yellow to green.

Mineral acids may be detected by their action on moistened blue litmus paper.

Oxidising gases, such as chlorine, bromine, oxides of nitrogen, and vapour of peroxide of hydrogen, liberate iodine from potassium iodide like ozone, but chlorine and bromine in any large quantity eventually discharge the blue colour struck with iodised starch paper.

Suspended matter.—Solid particles in the air may be collected by means of an aeroscope, which is simply a glass plate smeared with glycerine, on the sticky surface of which the air is made to impinge by being drawn through a very fine aperture in a glass tube. Another method is by drawing air through distilled water in wash bottles, permitting sedimentation, siphoning off the supernatant fluid, and examining the residue. Aspiration can also be conducted through a tube filled with sugar. The sugar is finally dissolved in distilled water, the entangled solid particles being thus obtained.

Micro-organisms.—Qualitatively, an idea of the micro-organisms present may be obtained by exposing a plate of some nutrient medium, usually gelatine, to the air. If it is required to make the examination specially localised, the plate should be guarded by a cylinder open at the top. The plate is then incubated at a suitable temperature. Quantitatively, the micro-organisms are best estimated by drawing the air through a Petri's sand-filter by a process of aspiration, the sand having been previously rendered completely sterile by means of heat. A known quantity of air is drawn through the sand, which is then shaken up in a definite amount of sterile distilled water; 1 c.c. or less of this may be used to make plate cultures, and the resulting colonies are counted.

Hesse's apparatus provides for the direct impingement of the suspended matter on gelatine, over which the air is gently drawn, and on the surface of which the colonies directly develop.

Amount of Air required.—Since air itself contains carbonic acid gas, and since man in the process of respiration is constantly adding thereto, it follows that the same air cannot be breathed over and over again without its eventually becoming toxic. Not only, then, is it necessary to provide a sufficient cubic space for each person, but the air of that cubic space must be frequently renewed.

1. Supply of Air.—Fresh air contains ·4 per 1000 parts by volume of carbonic acid, which is called its *initial impurity*. If this amount be increased, by respiration, combustion, or otherwise, to ·6 per 1000, the air in a closed space would smell musty to any one entering it directly from the open atmosphere. This smell is due to the organic matter which, as already seen, increases proportionately with the carbonic acid. The quantity of ·6 parts CO_2 per 1000 is therefore taken as the *limit of impurity*, *i.e.* the air of a room must not contain more than this quantity of carbonic acid, and in order to fulfil this condition fresh air must be supplied. It will be apparent that the addition of ·2 parts CO_2 per 1000 raises fresh air to the limit of impurity. ·2 is then the *respiratory impurity*.

How long does it take an average adult to raise 1000 cubic ft. of air to this limit? It takes twenty minutes. Why? Because the average adult gives off ·6 of a cubic ft. of CO_2 per hour, that is, ·2 in twenty minutes, and there being already ·4 in the air, the limit is thus reached. It is therefore obvious that the average adult will foul 3000 cubic ft. of fresh air per hour, so that, in order not to exceed the total impurity permitted, this quantity must be hourly supplied him. Calculations of air supply are made by means of the formula $d=\frac{e}{r}$, where $d\times 1000=$ the volume of air in cubic ft. required per hour (3000 per head), $e=$ the amount of CO_2 in cubic ft. given off per head per hour (·6 = the average), and $r=$ the respiratory impurity, *e.g.* ·2 of a cubic ft. CO_2 per 1000 cubic ft. of air.

Example.—Find the air supply required for 100 persons, so that the CO_2 shall not exceed ·8 per 1000 cubic ft. Here $r=$ total impurity minus initial impurity.

$d=\frac{\cdot 6\times 100}{\cdot 8-\cdot 4}=150$ and the volume of air required = 150,000 cubic ft.

Example.—If the air of a room contain ·1 per cent. CO_2, what amount of fresh air had been supplied per head per hour (·1 per cent. = 1 per 1000)?

$$d=\frac{\cdot 6}{1-\cdot 4}=\frac{\cdot 6}{\cdot 6}=1\times 1000=1000 \text{ cubic ft.}$$

Example.—If 2000 cubic ft. of air per head per hour be supplied, find the amount of CO_2 present. Here $2000=d\times 1000$. $d=2$.

$2=\frac{\cdot 6}{r}$, $r=\frac{\cdot 6}{2}=\cdot 3$, and the initial impurity being ·4, the total impurity = ·7.

Fresh air has not only to be supplied for the inmates of a room, but also to take the place of the air fouled by combustion, and more especially by gas jets. It is advisable to supply at least as much air for each ordinary burner as for each individual. A much larger quantity of fresh air must be supplied to the sick than to the healthy, especially in the case of lying-in hospitals and those for the treatment of communicable disease. From 4000 to 6000 cubic ft. per head per hour is necessary, and a similar amount is required in the case of mines and certain workshops. As regards animals, such as cattle and horses, too little air is often supplied, owing to the dread of cold, but from 10,000 to 20,000 cubic ft. per hour is required.

Organic matter is more offensive in a humid atmosphere than in a dry one, so that the addition of fresh air may not only dilute the impurities, but by rendering the air less humid further diminish the offensive odour.

2. Cubic Space.—Since each person requires 3000 cubic ft. of fresh air per hour, and since in this country the air of a room cannot be changed more than three times an hour without producing a disagreeable draught, it is evident that the amount of cubic space which must be supplied to each person is 1000 cubic ft. This holds good for children as well as adults, for though children at each exhalation do not give off so much carbonic acid as adults, yet they breathe more rapidly than adults, and so it is well to supply them with the same air space. Cubic capacity and air space do not mean the same thing, the latter referring to the space filled with air available for respiration. Therefore, in calculating the air space of a room, deduction must be made for furniture and the bodies of inmates. It is customary to allow 10 cubic ft. for bed and bedding, while the amount of air space which a man occupies can be obtained in cubic ft. by dividing his weight in stones by 4. The serviceable air space is that in which the air circulates, and thus excludes nooks and corners where

it lies stagnant. It is impossible in all cases to allow 1000 cubic ft. of air space per head, and the permissible limit in the case of houses may be taken as that which must be supplied to every inmate of a common lodging-house, namely, 300 cubic ft. A much smaller quantity is made to suffice in the case of canal boats, and in the case of rooms only occupied during part of the twenty-four hours, *e.g.* schoolrooms. The smaller the air space the more frequently must its contained air be changed, so that the chief advantage of large apartments is that they can be more readily ventilated without the production of draughts. They are not to be regarded as storehouses of fresh air. A height above 12 ft. does not materially add to the serviceable air space of an ordinary room, as the air movements above that level are, with the usual outlets and inlets, apt to prove of little account. Sick persons require more cubic space than do the healthy, in general hospitals 1500 to 2000 ft. being necessary. As regards animals, it is sufficient to note that cattle should have 800 cubic ft. of air space per head.

3. Floor space per head is the superficial area of the floor divided by the number of occupants. It is of special importance in connection with schools and hospitals. In the former from 8 to 15 square ft. per scholar is the amount recommended, in the latter each patient and his bed should have from 100 to 170 square ft. As a minimum it should be one-twelfth of the cubic space.

Calculation of cubic space.—The mensuration of cubic space is considered in the next section of this work, and will be found on p. 390. Cubic space enters into the calculation of air supply and air impurity, examples of which are here given.

Example.—What has been the air supplied per hour to a room containing five persons in which the CO_2 is ascertained to be ·8 per 1000?

$$d = \frac{e}{r} = \frac{\cdot 6 \times 5}{\cdot 8 - \cdot 4} = \frac{3}{\cdot 4} = 7\cdot 5 \times 1000 = 7500 \text{ cubic ft.}$$

Example.—Find the amount of CO_2 per 1000 volumes present in the air of a room having an available cubic space of 4000 cubic ft., and which has been occupied by ten persons for four hours, during which time 11,000 cubic ft. of fresh air have been supplied per hour.

$$r = \frac{e}{d} = \frac{\cdot 6 \times 10 \times 4}{4 \times 11{,}000 + 4000} = \frac{24}{48{,}000} = \cdot 0005 \text{ per unit} = \cdot 5 \text{ per } 1000.$$

$\cdot 5 + \cdot 4$ (initial impurity) $= \cdot 9$ cubic ft. CO_2 per $1000 =$ existing impurity.

Example.—What amount of air supply per head per hour is required to prevent the CO_2, rising above · 7 parts per 1000 in a hall of 50,000 cubic ft. of space occupied by 2000 people?

$$d = \frac{e}{r} = \frac{\cdot 6 \times 2000}{\cdot 7 - \cdot 4} = \frac{1200}{\cdot 3} = 4000 \text{ cubic ft.}$$

Therefore $d \times 1000 = 4{,}000{,}000$. From this must be subtracted the amount of air originally present, namely 50,000. $4{,}000{,}000 - 50{,}000 = 3{,}950{,}000$. As the amount per head is required, 3,950,000 must be divided by 2000.

Answer.— = 1975 cubic ft. per head for the first hour. In later hours $\frac{4{,}000{,}000}{2000} = 2000$ cubic ft. must be supplied, the original 50,000 being all used up.

AIR AND DISEASE.

The aerial transmission of communicable disease has already been in part considered, as have those occupational diseases induced by atmospheric dust. In the great majority of diseases attributed to atmospheric impurity, the air only acts as a medium of conveyance for the real noxious agent, be it vital (organismal) or inanimate (mineral dust, etc.). Carbonic acid is given off from the blood of the lungs into the air, but this is not so easily accomplished if the air contain an excess of carbonic acid. The relative tensions of the carbonic acid in the blood and that in the air are then altered, the respiratory balance is disturbed, and discomfort results. The air may contain so much carbonic acid as to be actively toxic, producing headache, vertigo, nausea, and anorexia, and if very large quantities (50 to 100 per 1000 volumes) are present, even a fatal result from asphyxia. Ophthalmia, both purulent and granular, may be directly due to irritating particles in the air, but an ill-ventilated atmosphere, apart from dust, certainly predisposes to this affection, particularly in children. Impure air, continuously inhaled, produces pallor due to anæmia, anorexia, languor, a tendency to skin affections, and a general lowering of vitality, which renders the body more prone to disease, and especially respiratory communicable diseases. True aerial transmission is most likely to occur in the case of those diseases produced by organisms which are capable of retaining their vitality and pathogenetic properties even in the dried state, namely, diphtheria, epidemic cerebro-spinal meningitis, and erysipelas. The germs of enteric fever and cholera require moisture, probably cannot long survive in dry dust, and are possibly devitalised by the drying power of air currents. The evidence regarding the *B. tuberculosis* is conflicting, some believing that it can remain virulent in the dust of rooms, and others, that the aerial transmission of tuberculosis is only possible when the virus is borne upon minute hygroscopic particles such as are expelled from the respiratory tract in the acts of coughing and sneezing.

SOIL.

Origin.—Soil consists of the disintegrated earth's crust, which through countless ages has been acted on by weathering forces such as wind, rain, snow, frost, and lightning; by ocean, river, lake, and glacier; by volcanic action, gases, and earth movements; by vegetation, by micro-organisms, by animal life, and by human agency. Combined with this rock débris there is the accumulation resulting from the decay of animal and vegetable matter. The character of the soil in different localities varies with the nature of the underlying rock, and with the variety and quantity of the animal and vegetable life which in times past it has sustained, together with the effect of those forces above enumerated. There is no sharp line of demarcation between what are known respectively as soil and subsoil. Soil signifies the surface layers, and contains more of the decayed animal and vegetable matter than does the subsoil, which in its nature is more closely related to the underlying rock strata. The soil proper, or the humus, rarely exceeds a few feet in depth, while the subsoil in some places extends for several hundred feet ere it merges with those formations to which it owes its origin. The earth's crust is formed of rock, which Professor Geikie defines as "any mass of organic or inorganic matter which is due to the action of natural causes, whether it be soft or hard, and whether it consist of one kind of species of mineral or of many species."

Composition.—The same minerals enter into the composition of many different kinds of rock, and the nature of the soil largely depends on the minerals which have gone to compose the rock.

Igneous rocks, such as granites and basalts, are divided into acid and basic according to the proportion of silica present. Granite, a type of the former, contains quartz, felspar, and mica, and decomposes into a gravelly clay soil owing to the disintegration of its felspar, which is soluble in water containing carbonic acid. Basalt, a type of the latter, becomes resolved into a clay marl.

Sedimentary rocks, which are classed according to the amount of clay, sand, or calcareous material they contain, the last-mentioned being inorganic or organic in origin, are more easily disintegrated than the igneous rocks, and yield soils consisting of sand, gravel, clay, or chalk.

Metamorphic rocks are igneous or sedimentary rocks which have undergone more or less complete change, and may form any of the soils above mentioned. Humus is a mixture of decomposed animal and vegetable matter together with the chemical elements of disintegrated rock. It contains pabulum for plants, such as salt of lime, potash, soda, and magnesia, phosphoric acid, nitrogen, and silica, with, in addition, certain organic acids, the function of which is but little known, and which are termed humic, ulmic, crenic, and apocrenic. Constant changes in the chemical composition of the humus are in large measure brought about by the micro-organisms existing in it, aided by the action of epigene agents, especially plants, rain, and gaseous interchange.

Physical Properties.—From a public health point of view the physical properties of soil are more important than its chemical constitution.

Pore Volume.—The grains of which the soil is composed are so arranged as to have interstices between them, and these interstices are filled with air. In any given bulk of soil a certain proportion is due to these pores, which form one-third to one-half of the total bulk. The pore volume is ascertained by determining the real and apparent specific gravity of the soil. The specific gravity of the soil is the ratio of the weight of the soil to the weight of an equal bulk of water. The apparent specific gravity is obtained by weighing the soil. The real specific gravity is obtained by filling the pores of the soil with boiled distilled water, weighing it thus, and deducting the weight of water required to fill the pores. The apparent specific gravity, divided by the real specific gravity, gives the proportion of the apparent specific gravity due to soil alone, the remainder being the proportion of pore volume in the soil.

Example.—Let a soil have an apparent sp. gr. of 1·5, and a real sp. gr. of 2·5. The pore volume is 40 per cent.

$\frac{1 \cdot 5}{2 \cdot 5} = \cdot 6 =$ sp. gr. due to soil alone. The remainder is ·4 or 40 per cent.

Another method of estimating pore volume is to fill the pores with CO_2, and calculate their volume from the amount of CO_2 required.

Permeability.—The permeability of a soil depends on the size of its pores, and this on the size of the grains of which it is composed. The larger the grains, the greater the rate of permeability. The smaller the grains, the more exposed surface, the greater the friction, and the less the permeability.

The pore volume of a soil may be equally great with that of another, and yet they may vary much in their permeability, owing to there being a difference in the size of the grains of which they are composed.

Water Capacity of a soil is the percentage of its pore volume which can be kept full of water by capillarity. This depends upon the size of the pores, the smaller the pores the greater being the water capacity. It is determined by experiment, the soil being packed in a cylinder and weighed, water allowed to rise through it from below, and the difference in weight thereafter being noted and the calculation made.

Porosity has to be distinguished from pore volume and permeability. It bears no relation to the interstices of the soil, and we prefer to define it as the facility with which the soil grains allow water to pass through them apart from its passage through the pores between them.

Temperature.—Soil derives its heat mainly from the sun, absorbs it more quickly, and parts with it more rapidly, than does water. In certain places the surface of the earth is warmed by the internal heat of the globe through the agency of volcanoes, hot springs, and outlets for imprisoned gases. Apart from these factors, the influence of this source of heat becomes more and more apparent the further you descend from the surface, the temperature increasing 1° C. for every 100 ft. of descent. A further origin of heat is the chemical interchange constantly going on in the soil.

Absorption and Radiation.—The absorption of heat by the soil depends on the nature and colour of the soil, the vegetation it sustains, and the moisture present in it. Soils vary in their specific heat, none having so high a specific heat as water. For example, the specific heat of water being 1, that of sand is ·27, that of humus ·6, and of clay ·16. If heat absorption depended alone on the specific heat of the soil, it is apparent that a clay soil would be readily heated, while the reverse is the case, owing to the large quantity of moisture it contains and the high specific heat of water. Dark-coloured soils absorb heat more readily than do those of a light colour. Vegetation may hinder absorption by intercepting the sun's rays, cooling the air by evaporation from leaves, and directly checking soil evaporation. On the other hand, it absorbs much of the soil moisture, and thereby renders the soil more capable of heat absorption. The chief effect of trees and shrubs, however, is to cool the soil. Herbage acts in a similar manner.

Radiation.—Soils cool more rapidly than water, and less rapidly than air. The radiating power of soil is usually more rapid than its absorbing power, and rock radiates heat more rapidly than a grass-covered surface.

Retention.—Schübler's observations show that soils vary in their power of retaining heat, so if sand with some lime corresponds to 100, pure sand will be 95, clay 70, chalk 60, and humus 50.

Daily and Annual Variations.—Diurnal variations are of more importance in connection with the surface soil, annual variations with the subsoil. The surface soil and the atmosphere rarely coincide in temperature, the soil being warmer than the air by day and colder by night. This daily variation is only perceptible down to 3 or 4 ft. from the surface in temperate climates, and varies with the nature of the soil and with the season. The layers under the surface take some time to respond to the heat stimulus from the atmosphere, a hot day not making itself felt in them till a considerable time has elapsed. Annual variation of temperature can be demonstrated at depths of less than 24 ft., but vanishes completely at about twice that depth. Annual variations depend on the differences between the summer and winter temperatures, and on the conductivity and specific heat of the soil. Heat penetrates the earth but slowly, and at a depth of 24 ft., as shown in Edinburgh, the wave of summer heat produces a maximum temperature in January, whilst soil at this depth reaches its lowest temperature in midsummer. The mean annual temperature of the soil surface is lower than that of the air resting upon it, owing to nocturnal radiation cooling the earth, and solar radiation warming the superincumbent air.

Determination of Earth Temperature.—This is done by thermometers, usually at depths of from 1 to 4 ft. The instruments are suspended in hollow cylinders driven into the ground, and are protected above by open wooden covers. The surface temperature may be obtained by a flat coil thermometer laid on the ground.

Power of Reflecting Light.—This, which has considerable hygienic interest, depends on the colour of the soil and the presence or absence of herbage and of snow and ice. White or light-coloured soils, such as are met with on seashores and in sandy dèserts, reflect light very strongly, so much so that the glare becomes painful to the eyes, and is apt to induce conjunctivitis. Houses built in such places should not be of a staring white colour, but should be painted of such a hue as to rest the eyes, preferably a pale green tint. Protection of the eyes by coloured or smoked glasses is specially necessary when travelling over snow-clad wastes or frozen tracts, the perpetual white gleam being exceedingly trying, and inducing the condition known as snow blindness, consisting of photophobia and conjunctivitis. The absence of herbage always tends to render soil wearisome to the eyes, increasing its power of reflecting light.

Moisture.—This, at the outset, must be distinguished from the ground water, with which, however, it is intimately associated. By soil moisture is meant that water retained partly by capillarity in the upper layers of the soil and replenished by the rainfall. The interstices of this part of the soil are not completely filled with water, as they are at deeper levels. The presence of moisture in the upper layers of the soil depends upon the rainfall, the rise and fall of the ground water, the evaporation from the surface of the soil, and through the soil from the surface of the ground water, and the retentive effect of capillarity. No soil, even when composed of the hardest granites, densest clays, and most flinty limestones, is impervious to rain, which, when it falls on a surface, in part evaporates, in part percolates, and in part, to coin a word, "inclinates," that is, flows down the adjacent slopes to the most accessible watercourses. Damp soils tend to occur where the level of the ground water is persistently high, and to a lesser extent where it constantly fluctuates. Evaporation from the soil surface tends to dry the upper layers, while evaporation through these latter from the surface of the ground water produces an opposite effect. Water may be maintained by capillarity in the soil above the level of the ground water to a varying height dependent upon the nature of the soil. It is greatest in clay, and least in chalks. Although all soils are more or less permeable, they may be divided roughly into permeable and impermeable, since their permeability varies within very wide limits. Chalk, sands, sandstone, and gravel readily permit the passage of water through them; while hard rock, dense clays, and slates are types of soil which may be termed impermeable. Permeable soils may be said to be the supply pipes whereby rain reaches the ground water. Impermeable soils as a rule retain as moisture any water which soaks into them, and but slowly pass it on to the ground water. The soil moisture is greatest at the end of winter, and diminishes during summer in temperate climates. In the tropics it is excessive towards the end of the rains, while in the dry season the soil may hardly contain any moisture at all save that supplied to it by the ground water. A certain amount of moisture in the soil is necessary for the process of decomposition of organic matter, which is retarded when there is either excess or deficiency. The moisture is determined by taking a known weight of soil, drying it in a hot chamber, allowing it to cool, and then weighing it. The process is to be repeated till a constant weight is attained. The loss in weight will then represent the amount of moisture which was present.

Ground or Subsoil Water.—Part of "the waters under the earth" are bounded above by a permeable, below by an impermeable stratum. Above the level of the ground water there is a zone of evaporation and capillarity, and above this the interstices of the soil are usually filled with air. The ground water is really a sheet of water moving slowly through permeable soil. This area of saturation is found at different levels in different places, and its surface level tends to rise and fall, and, indeed, may fluctuate within wide limits. Further, there is a general movement of the water sheet towards its outlets, namely, the sea, rivers, and springs. In this connection it is to be noted that ground water frequently feeds streams and lakes by means of springs opening in their beds. While thus travelling, it follows the external configuration of the land through which it moves, rising high in the interior of mountains, and passing under valleys. The level at which the ground water is encountered depends on the nature of the soil which overlies it, the proximity or otherwise of the impermeable layer beneath it to the land surface, the quantity of the rainfall which percolates, the facility of outlet, and the physiographical features of the district examined. In some places, such as marshes, it may be level with the surface; in others, borings of several hundred feet may have to be made before it can be tapped. The movement of the ground water is influenced by gravity, and its rate varies with the gradient, the nature of the soil traversed, the ease of outlet, and the obstruction it encounters in its peregrinations, such as when it meets the roots of trees. The rise and fall of the ground water differs greatly in different localities, and at different seasons of the year. In hot climates, such as India, its level may in the wet season closely approach the land surface, while in the dry period of the year it is seldom within 15 to 20 ft. of it. The causes of this fluctuation are rainfall, tides, river pressure, and the conditions and number of the outlets, which may become diminished or increased in size or number. In plains the level may be raised by heavy rainfall in neighbouring or distant hilly country, provided there be no intercepting valley. Ground water level is measured by observing the height of water in wells, which may be done, as Pettenkofer recommended, by the use of a vertical staff, on which are fixed cups at known distances one above the other, and noting the highest cup filled when the staff is lowered down a well. To ascertain the ground water level of a district, many wells must be frequently and simultaneously examined. Another method is by means of an index connected by a cord with a float, which records automatically when the float reaches the water surface. What has been said refers solely to the more or less superficial ground water. There is, however, in addition, a deep ground water situated between two impermeable strata, and, if the geological formation permits, forming vast natural reservoirs, such as are met with in the chalks and limestones. Such ground water bears important relations to water supplies, and may be tapped by artesian wells.

Ground Air is atmospheric air together with the products of soil metabolism, but lacking some of the aerial oxygen. It also differs from atmospheric air in containing more moisture, more carbonic acid, and more organic matter. Ammonia, sulphuretted hydrogen, marsh gas, carburetted hydrogen, and bisulphide of carbon, are occasional constituents. The ammonia and the sulphuretted hydrogen are usually fixed as salts, the former by the humic acid, the latter as sulphides. Its composition, unlike that of atmospheric air, is not constant, but varies in different places and at different times and seasons. No micro-organisms have been found in ground air. The ground air of pure soils, such as is met with in the Saharan desert, is very nearly identical in composition with the atmospheric air. The ground air of towns may contain coal-gas which has escaped from gas pipes. The carbonic acid, which in atmospheric air forms by volume only ·4 parts per 1000, in ground air forms as much as from 10 to 160 parts per 1000. The quantity increases with the depth from which the ground air is taken, and is in excess where decomposition is going on. There are diurnal and seasonal variations, as in atmospheric air. The former are exactly the reverse of the atmospheric variations, there being most carbonic acid in the ground air in the morning during autumn, and in the evening during spring. The latter show the carbonic acid to be highest in summer and lowest in winter. The excess of carbonic acid may be due to the chemical changes, more especially the decomposition of organic matter, constantly proceeding in the soil, and in which action micro-organisms play an important part. There is a lesser quantity of it in the upper layers owing to aeration. When the soil pores are sealed by rain, the deeper layers cannot be efficiently ventilated, and carbonic acid accumulates. Hot weather has the same ultimate effect, because the atmosphere becomes hotter than the ground air, and an interchange is thus prevented, while decomposition is at the same time favoured. In cold weather, if the temperature of the ground air rises above that of the atmospheric air, soil ventilates itself, and the carbonic acid is consequently reduced. Rain may play a part in diminishing it by increasing the moisture of the soil, the water dissolving the carbonic acid. The quantity of carbonic acid in the ground air is a better indication of the permeability of the soil than of its impurity, since even an impure soil, if freely ventilated, will get rid of much of its carbonic acid. Fodor, however, has pointed out that while the carbonic acid increases with the depth, the organic matter and chemical changes diminish, and thus the origin of the gas cannot as yet be definitely settled. The amount of carbonic acid is determined by aspirating the ground air up iron or leaden tubes with perforated ends sunk in the soil by means of borers to varying depths, and from them through special glass tubes charged with baryta solution or lime water. The rate of aspiration must be slow, and the examination must not be conducted for some time if holes have been dug for the reception of the tubes, so that the soil may regain its normal condition.

The amount of oxygen diminishes with the depth, and the oxygen combines with carbon, hydrogen, and nitrogen to form carbonic acid, water, and nitrous oxide, hence its lessened total quantity. It is important to remember that the humidity of ground air is much higher than that of atmospheric air, the former being constantly in contact with moisture. Ground air, like ground water, is in a state of constant movement, due to the fluctuations in the ground water, temperature, barometric pressure, and also to the action of winds and percolating rain. Winds and the fall of barometric pressure act by aspiration, rain by temporarily sealing the surface pores and driving the ground air downwards and laterally. The air thus displaced naturally finds an exit through that portion of the ground, the surface of which is unwetted, such as parts covered by buildings, into which the air rises. This is aided by the aspirating action of the warmer, and therefore lighter, air in the buildings. The amount of ground air present in soil may be as much as 40 per cent., and only the very hardest rocks contain none of it. The simplest way of estimating it is by Renk's method. Take a measured volume of soil, shake it well together, place it in a graduated glass vessel, pour in sufficient water to amply cover it, shake till all air is expelled, allow it to stand a little, and then read off the point at which the water stands. The volume of soil, plus the volume of water used, minus the last reading, gives the volume of the soil which has been occupied by ground air. In a piece of rock the determination is made by weighing the rock dry (w) and saturated (w_1), subtracting the one weight from the other, dividing the result by the weight when dry, and multiplying by the specific gravity of the rock and by 100 to express it as a percentage. Thus $\frac{w_1 - w}{w} \times$ sp. gr. $\times\ 100 =$ the percentage of ground air present.

Organic Matter in Soil is derived from animal and vegetable matter, which may be fresh or in any stage of decomposition, and is to begin within the form of complex compounds which become resolved into carbonic acid, water, oxides of nitrogen, and ammonia. A few organic compounds can pass through soil without being changed, *e.g.* naphthylamine, thymol, salicin, and asparagin (Falk.). The organic matter may contaminate the ground water if the soil is saturated, and the moisture dissolves out the organic matter and carries it to the lower levels, or if in prolonged drought fissures are formed in the soil so that subsequent rain can easily carry it downwards from the surface. Contamination of the soil with organic matter has an important relation to the health of dwelling sites, which will be discussed under the part dealing with Soil and Disease. It is estimated as free ammonia and organic nitrogen. (*a*) As free ammonia. This consists in setting free the ammonia by acting on the soil with strong caustic soda. The ammonia is then absorbed by weak sulphuric acid, and its amount estimated by titration with weak caustic soda, the lessening in the acidity of sulphuric acid being determined with litmus as the indicator. The result is expressed as grms. per cent. (*b*) As organic nitrogen. This is done by Kjeldahl's method, in which the soil is submitted to the action of strong sulphuric acid and heat, which, aided by the addition of permanganate of potash, converts all the nitrogen of the soil into ammonium sulphate. This is washed out of the soil and distilled with ammonia-free caustic soda. Ammonia is given off and received into a solution of oxalic acid, which is titrated, the diminution in its acidity being noted and the ammonia calculated therefrom. From this must be deducted the quantity of free ammonia present as already determined. From the ammonia of the result, the nitrogen, which constitutes $\frac{14}{17}$ of the ammonia, is calculated, and is expressed in grms. per cent. of the original soil. Professor Hunter Stewart's modification of this method provides for the joint estimation of organic carbon and organic nitrogen. The latter is determined as in Kjeldahl's process; the former is calculated as carbonic acid. For this purpose the air supplied for combustion is freed from carbonic acid and ammonia by passing it through bulbs and tubes containing strong sulphuric acid, soda lime, and calcium chloride, and the gaseous products of combustion are passed through permanganate of potash to free them of sulphuric acid, and through silver nitrate and barium nitrate to get rid of chlorine and sulphuric acid, the CO_2 being finally collected in special tubes containing baryta solution. An essential preliminary is to treat the soil with a few drops of weak sulphuric acid for the purpose of decomposing the carbonates present.

Micro-organisms.—These are present in soil in large numbers, and are of various species. The upper layers of the soil contain many more organisms than the deeper layers. At a certain depth, which varies with the locality, microbes abruptly decrease, and are finally absent; indeed, the upper strata of the soil would appear to act as an excellent microbial filter. The small amount of oxygen and the large amount of carbonic acid in the ground air at deeper levels no doubt militate against the presence of micro-organisms. Sand is poorer in microbes than either clay or humus; while cultivated soil, and soil in the neighbourhood of towns and human habitations, and that of graveyards, contain bacteria in much greater numbers than so-called virgin soils. Buchanan Young has demonstrated the interesting fact that, in the case of graveyards, the increase is in the deeper layers of the soil, and corresponds with an increase in the organic matter. Though the majority of soil microbes are aerobic, a certain number of anaerobes also make it a nidus. Many bacilli no doubt retain their vitality in the soil in the form of spores, when otherwise they would be unable to resist the inimical conditions to which they are exposed, such as want of oxygen, the action of other organisms, the paucity of aliment, the absence of moisture or its presence in excess, and perhaps, as in peat, the antagonism of certain acids. The chief pathogenetic organisms known to exist in soil are the bacilli of anthrax, enteric fever, malignant œdema, plague, and tetanus, the spirillum of cholera, the *B. enteritidis sporogenes*, the *B. septicus agrigenus* found in garden earth, and the *Micrococcus septicus*. Possibly an organism associated with epidemic diarrhœa also exists, though so far it has not been isolated. There are a great variety of saprophytes, such as *B. butyricus, candicans, coli communis, denitrificans, diffusus, mesentericus vulgatus* (potato bacillus), *muscoides, mycoides, nitrificans, proteus, ramosus, scissus, subtilis,* and *thermophilus*, and the common root bacillus. Some of these combat the pathogenetic microbes and play an important part in oxidising and deoxidising organic matter. It has been shown that certain of them are necessary for plant vitality. In sterilised soil containing all the other requisites for vegetation, plants will not flourish, developing feebly and eventually dying.

Nitrification and Denitrification.—Each variety of organism probably plays its own part in these processes. The first stage is the alteration of organic matter, being one of peptonisation, evidenced by liquefaction, wherein the oxygen is removed. Then the organic matter is further split up into compounds of carbon, hydrogen, nitrogen, sulphur, and phosphorus. This stage is believed to be due to thea ction of anaerobic organisms. These compounds, such as sulphuretted hydrogen, ammonia, phosphuretted hydrogen, and compounds of carbon and hydrogen, are next acted upon by oxidising microbes, among which are the so-called nitrifying bacilli, and the resulting products are water, carbonic acid, sulphuric acid, and nitrous and nitric acids. Salts, such as sulphites and sulphates, nitrites and nitrates, are finally formed by a combination of these acids with the bases, potash, lime, and magnesia, present in the soil. The reverse process is caused by the denitrifying bacteria, which break up those salts into their component elements. The bases mentioned are essential for a continuance of both actions. A certain temperature, a certain degree of moisture, and a supply of oxygen, are also required.

Estimation of Micro-organisms.—For this purpose a sample of soil must be collected with the ordinary bacteriological precautions, and its weight ascertained. Earth from different depths may be obtained by means of a Fränkel's borer. This is broken up in a definite quantity of sterile distilled water, and plate cultivations are made from the liquid. The resulting colonies can then be counted, and the number of micro-organisms in the whole sample calculated. The microscopic examination of the colonies shows the variety of organisms present, and further aerobic and anaerobic cultivations in suitable media can then be carried out.

Classification of Soils.—From the point of view of the hygienist, soils are classed as healthy and unhealthy. The main determining factors are—(1) the quantity of organic matter present; (2) the amount of moisture; (3) the level and fluctuations of the ground water; (4) the nature of the ground air; (5) the geological structure with reference to cold and warmth; (6) the facilities for natural drainage of the soil; (7) the vegetation supported.

These points are better discussed in the consideration of building sites, and will be found on p. 304.

Considering soils with regard to their geological formation alone, which after all is of less importance than the purely local factors, it is found that those formations which favour slope, dryness, warmth, and a moderate vegetation, and which yield little or nothing to the atmospheric air and the ground water, are the healthiest. Such conditions are fulfilled by soils composed of the harder rocks, such as granite and basalt, gneiss and clay slate, as long as they remain unweathered. The same may be said of millstone grit and the oolitic limestones. Gravelly soils, if well drained, are excellent, but if in hollows tend to be damp, the ground water standing at a high level. Chalk, sandstone, and sand are healthy when unmixed with clay, which renders them impermeable, cold, and damp. The magnesian limestones favour marsh formations. Alluvial soils as a rule are unhealthy, having little or no slope, being often damp, and favouring rank vegetation. Sandstones, limestones, chalk, and alluvial soils all tend to yield impurities to the ground water. These are usually of a mineral nature, but may be organic, especially in the case of the last-named. It may be noted that well-cultivated land is by no means unhealthy, but ground constantly irrigated for agricultural purposes is liable to become so, being frequently rendered water-logged and damp, while the moisture favours organic decomposition.

SOIL AND DISEASE.

The relation of soil to disease is a question of primary importance, and yet one which in many instances is obscure. This is in large measure due to the fact that soil may prove itself a determining factor in the production or aggravation of disease by acting in divers manners, while its various constituents, such as the ground air, ground water, carbonic acid, organic matter, and micro-organisms, may all be concerned, or may possibly act separately. Thus soil may be implicated because—

1. It affords a habitat for pathogenetic micro-organisms, which from it can invade man, directly or by means of drinking-water, wind-blown dust, or insects carrying infected dust particles.

Examples.—Plague, tetanus, enteric fever.

2. It may itself, in the form of fine, irritating dust, be inhaled or swallowed, and act mechanically, producing abnormal conditions. Some cases of dysentery are in all probability due to the ingestion of gritty particles of sand and dust.

3. It may yield certain mineral matters to ground or river water, which may then, when used for drinking purposes, excite disease.

Examples.—Calculus and goitre. The dependence of these diseases on this cause is not definitely proved.

4. It may by its dampness predispose to certain diseases.

Examples.—Phthisis, diphtheria, chronic rheumatism, neuralgia.

5. It may in some obscure manner, dependent upon the conditions of its contained air and water, influence the outbreak of epidemics.

Example.—Cholera.

6. Its organic pollution and temperature may be such as to possibly favour the production by micro-organisms of volatile poisons, which perhaps pass out in the ground air, and may contaminate food-stuffs.

Example.—Epidemic diarrhœa.

7. It may harbour the dead bodies of insects containing the microbes of communicable disease, which may be set free in dust as when a soil is broken up.

Example.—Malaria.

8. It may form the habitat of parasites which infect man.

Example.—Many nematode worms, such as, to cite a good instance, *Ankylostomum duodenale.*

9. It may so influence ground or river water as to give it special solvent powers, whereby it may take up deleterious substances.

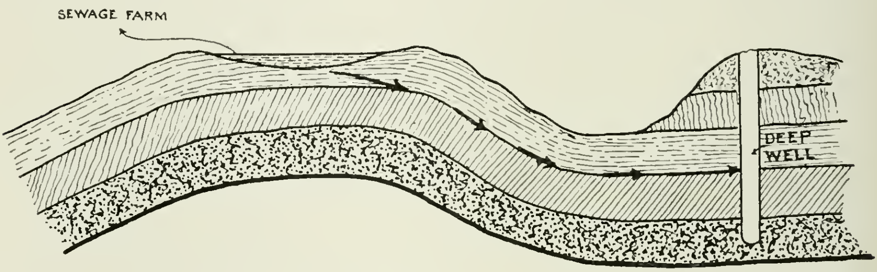
Example.—Lead poisoning.

10. By its mere geological formation it may bring about contamination of a water supply, which might otherwise have been safe from specific infection. True, this scarcely comes into the present category, but it must not be overlooked, and an example is seen in the case of a sewage farm polluted by enteric excreta and placed on the summit of an old anticline. The sewage soaks into the exposed, permeable strata, which may conduct it long distances to underground reservoirs tapped by wells (Fig. 63).

The following diseases appear to be more or less intimately connected with soil conditions: anthrax, beri-beri, calculus, cancer, cerebro-spinal fever, cholera, epidemic diarrhœa, diphtheria, dysentery, enteric fever, goitre, lead poisoning, malaria, malignant œdema, parasitic disorders, phthisis, plague, rheumatism, tetanus, verruga, and yellow fever.

Those diseases in this list which are termed communicable have already been fully considered in the section devoted to Medicine, but the relation of some of them to soil may here be a little more extensively discussed, while the other diseases require some attention.

Anthrax is related to the soil, owing to the fact that the bacilli or their spores exist in certain soils, so that they can infect cattle, drinking-water, etc. They gain access to herbage and soil from the discharges of animals suffering from the disease, and from infected carcases foolishly cut up or dragged about, instead of being at once disinfected and buried whole or burned. Pasteur believed that earthworms could carry up the spores from the deeper layers of the soil to the surface, but bacteriological examination of earthworms has yielded no proof in support of this theory. Further, spore formation can only occur in the presence of oxygen, and under a favourable temperature. At certain times of the year anthrax-sown fields are apt to be specially dangerous, probably because the conditions then favour a development of spores into



SEWAGE FARM ON OLD ANTICLINE

FIG. 63.

bacilli. Soils containing lime favour sporulation, and the spores are extremely viable, and may remain in a dry condition unaltered for a year or more. Moist soils, rich in humus, are suitable at the hot time of the year for the change of spores into bacilli. Putrefactive processes destroy the bacillus, but not the spores. The value of burying the complete carcase, or still better of burning it, is therefore apparent.

Calculus.—Any influence which soil may exert upon the prevalence of calculus must depend upon what it yields to the water supply. Possibly the constant imbibition of water charged with salts of lime favours the retention and deposition of the products of metabolism in the body, which a purer water supply ought to dissolve out. Calculus, however, is not confined to districts situated on the chalk or limestone, and is not universal even in such districts. Norfolk and the eastern English counties, the basin of the Don and Volga, part of Canada, etc., are chalk and limestone regions where calculus is prevalent; while in portions of the Alps, though the drinking-water is very hard, the disease is rare.

Cancer.—Efforts have been made to show that cancer is more prevalent in low-lying, damp situations, with clay soils, such as are met with in the Thames valley, but it is extremely probable that soil has no bearing whatever upon the disease.

Cholera is intimately associated with soil conditions. For its epidemic spread three conditions must be satisfied—(*a*) the presence of the specific microbe; (*b*) a suitable soil nidus; (*c*) susceptible persons. These constitute respectively the *x*, *y*, and *z* of Pettenkofer. The microbe is voided from the bowels of infected persons, but in the soil is only viable if supplied with a definite amount of heat and moisture. Too much or too little of these agents is alike inimical to its life and growth. The cholera vibrio does not live more than a few days in soil which is quite dry, which is acid, or which is saturated with water. Under favourable conditions it has been known to remain alive for a period of six months, but Houston found that when sown broadcast on soil in the open it speedily decreased in numbers. In India rain may either favour or prevent an outbreak of cholera, according as the soil has, previous to the rainfall, been dry or moist. In the latter case the organism has, so to speak, been "drowned out." It is to be noted, therefore, that the curves of rainfall and cholera do not coincide. Their relations vary in different places according to the amount of rainfall. Thus, in Lahore, with a rainfall of about 20 in., the heaviest rainfall only moistens the soil sufficiently to favour the presence of the organism, and the highest point of the cholera curve follows that of the rainfall. In Calcutta, with a rainfall of over 60 in., the maximum fall completely soaks the soil, and "drowns out" the microbe, hence the highest point of the cholera curve precedes that of the rainfall. Organic pollution which is associated with an alkalinity of soil is favourable to cholera outbreaks. In some places the prevalence of epidemics has been noticed to be coincident with a rise in soil temperature, and European epidemics have, as a rule, occurred during hot summers. Soil temperature seems to have little to do with the disease in India, though moisture plays an important part. Pettenkofer connected outbreaks of cholera with alterations in the level of the ground water. Briefly put, his views were that cases increased as the ground water fell, and decreased as it rose, the fall of the subsoil water leaving the soil moist, aerated, and in just the condition to further the activity of the specific microbe, while its rise "drowned out" the germs. Another assumption has been, that the rise and fall of the ground water influenced the contamination of wells. The level of the ground water in Calcutta is highest in September and lowest in May, while cholera reaches its height in May and is at a minimum in September. A permeable soil, especially one in which the ground water fluctuates, is par excellence the habitat of the organism of cholera. It has been noticed that places situated on hard rock may escape epidemics, while neighbouring localities, not so favourably placed, suffer.

The curve of cholera prevalence may be parallel with that of the amount of carbonic acid in the ground air, the latter being an index of the organic matter present in the soil, and indicating that the upper soil layers are not saturated with moisture. In India this does not obtain. Lewis and Cunningham have shown that there is most cholera when there is least carbonic acid in the ground air. It has been suggested by Naegele that possibly the cholera vibrio requires another organism which acts as its forerunner, in other words, a microbe which is absorbed and lessens immunity, or increases susceptibility. This may be the rôle of some variety of coliform bacillus. Hueppe believes that a sojourn in the soil increases the resistant action of the vibrio, enabling it to safely run the gauntlet of the stomach juices when taken in along with drinking-water.

Epidemic diarrhœa.—There is a close connection between this disease and the soil, especially the soil temperature. Ballard long ago pointed out that—

(*a*) "The summer rise of diarrhœal mortality does not commence until the mean temperature recorded by the 4-ft. earth thermometer has attained somewhere about 56° F., no matter what may have been the temperature previously attained by the atmosphere or recorded by the 1-ft. thermometer.

(*b*) "The maximum diarrhœal mortality of the year is usually attained in the week in which the temperature recorded by the 4-ft. earth thermometer attains its mean weekly maximum.

(*c*) "The decline of the diarrhœal mortality . . . coincides with the decline of the temperature recorded by the 4-ft. thermometer, which temperature declines much more slowly than the atmospheric temperature, or than that recorded by the 1-ft. earth thermometer.

(*d*) "The influence of the atmospheric temperature, and of the temperature of the more superficial layers of the earth . . . is little if at all apparent until the temperature of the 4-ft. earth thermometer has risen as stated above ; then their influence is apparent, but it is a subsidiary one."

Besides earth temperature, the conditions of soil bearing on epidemic diarrhœa are its organic pollution, its permeability, moisture, and ventilation. Foul soils favour diarrhœa. Permeable soils generally conduce to diarrhœa, as do those containing a moderate amount of moisture. As regards ventilation, there appears to be some relation between the disease and the fall of carbonic acid in the ground air, since an increase in diarrhœal mortality has been noticed in Edinburgh to occur one week after the fall of carbonic acid in the ground air. As the soil is ventilated, there probably passes out of it some unknown organism or volatile poisonous product of an organism which is the causa causans of the disease. Some believe that dust plays an important part, and others have hazarded the opinion that the specific microbe is the *B. enteritidis sporogenes*.

Diphtheria is apt to prevail upon cold wet sites, though Löffler's bacillus is not found in the soil. Conditions favouring damp soils, such as a high level of the ground water, are therefore those under which many believe diphtheria to be common. While this may be true of isolated cases, the action possibly being merely one of lowering vitality, Newsholme has pointed out certain pregnant facts regarding extensive epidemics. Such epidemics do not occur when, for several successive years, the rainfall has been above the average, nor in any year of very high rainfall unless the preceding years have been dry. A dry year, and more especially a succession of dry years, coincide with the greatest epidemics of diphtheria. In these years the level of the ground water is low, and he regards this as the usual accompaniment of epidemic diphtheria. It is to be noted that scarlet fever and erysipelas, which so frequently coexist with diphtheria, commonly occur in excess during dry years. Diphtheria is rare on the plains of India and the South African plateau, although it occurs on all varieties of geological formation.

Dysentery has practically disappeared from Great Britain since the low-lying marshy tracts where it flourished have been drained. Such kinds of soil favour the disease, but probably only because they lower the general health and tend to induce chills. Organically polluted soils are also connected with dysenteric outbreaks, while soils with an irritant surface dust exposed to violent wind action, as in South Africa, may originate dysenteric symptoms in those predisposed. The soil may possibly form a nidus for some organism connected more or less specifically with the disease, but there is no evidence to this effect.

Enteric fever.—The conditions of soil favouring cholera are also those under which enteric fever flourishes and propagates itself, with the notable exception that soil temperature seems to play no part. In many places the influence of the ground water is not visible, in others enteric is most frequent according to its range of fluctuation, and reaches its maximum when the ground water is low in level. The bacillus of enteric fever may find a nidus in the soil, but its growth therein must depend largely on the nature of the soil. Martin found that sterilised virgin soils were not favourable to its growth, but that sterilised cultivated soils nourished it for long periods. In unsterilised soil which was artificially contaminated, the *B. typhosus* was with difficulty recoverable, and could not be found after twelve days. The conditions prevailing in the surface layers of the soil are probably inimical to the life of the bacillus (Houston). The *B. typhosus* is a less hardy organism than many of those, such as *B. coli communis*, which would be present in soil contaminated with excreta. Whatever may be the case in soil, there is no doubt that in artificial culture media the *B. coli communis* tends to "crowd out" the bacillus of enteric fever from a mixed culture of the two organisms.

At present it can only be said that the precise relationship between the soil and the *B. typhosus* requires further elucidation.

Goitre occurs endemically in mountainous regions having magnesian limestone as their main geological formation. It affects not only natives but residents, and removal from the locality frequently results in benefit. The connection of goitre with the soil is, however, not clearly made out, since the disease is absent from some districts of this formation, and yet known in places where there is no magnesian limestone. The presence of metallic salts, such as those of iron and copper, which are not infrequent in limestone regions, has been advanced as an explanation, but is as little satisfactory, and for the same reasons. Damp valleys at high altitudes are said to be the homes of goitrous subjects.

Lead poisoning.—It has been found by Houston that in peaty soils certain micro-organisms exist which are capable of producing an acid of the fatty series, and thereby acidifying water which has passed through or over this soil. Water so contaminated has a powerful plumbo-solvent action.

Malaria.—The conditions of soil favouring malaria are those which render it suitable for the life and reproduction of the mosquito. These are—(1) a high level of the ground water; (2) saturation; (3) insufficient drainage and outlets, resulting in the formation of stagnant pools; (4) the presence of rank and rotting vegetation; (5) irrigation as in rice fields; (6) a temperature of from 20° to 25° C. Further, it is possible that dry powdered mud from evaporated mosquito-haunted pools, and the dust from broken-up soils containing the dead bodies of infected mosquitoes, may play a part in the production of the disease.

Phthisis.—A cold, damp soil conduces to phthisis mainly by inducing catarrhs and lowering the general health of those who live upon it, so that they become predisposed to the pathogenetic action of the tubercle bacillus. Drainage has markedly lessened phthisis mortality.

Plague.—The bacillus of plague finds a habitat in the soil, especially if the latter be organically polluted. Alluvial and marshy soils were supposed to be specially favourable to plague, and in its endemic form this may be the case. As an epidemic, however, plague flourishes on soils of various nature, but there can be no doubt that contamination with organic matter gives the organism a firmer foothold.

Rheumatism in its chronic form persists on damp soils, while rheumatic fever is totally different, occurring after seasons of sparse rainfall, when the soil is warm and dry and the level of the ground water is low.

Tetanus and **malignant œdema** are types of diseases in which the specific organism finds a natural habitat in the soil, and can usually be demonstrated in garden soils, stable earth, and organically polluted soils.

Yellow Fever is associated with a permeable, moist, and organically polluted soil, which is apt to become saturated by the ground water or by the periodic overflowing of rivers. It may be that the organism grows and multiplies therein, or the relation of the disease to the soil may be somewhat similar to that of malaria.

Purification of Soil.—This is attained by—(1) limiting the amount of vegetable and animal organic matter allowed to reach it, as seen in the use of refuse destructors; (2) thorough disinfection and purification of dangerous and offensive discharges, sewage, and filth, before they reach the soil; (3) drainage of the subsoil; (4) ploughing and aeration; (5) the encouragement of certain forms of vegetation, *e.g.* eucalyptus; (6) firing, as employed in the case of soils polluted with excreta containing parasites or pathogenetic micro-organisms; (7) the regulation of offensive trades, factories, and workshops.

WATER.

Introductory.—Of all vital requisites water is the most essential. It has decided in large measure the distribution of man over the globe, and at the present day in sanitary matters its consideration takes precedence over all other questions. A wholesome and liberal water supply is essential to every community, not only for alimental use, but for purposes of personal and general cleanliness, trade and manufacture, and safety against fire. In many instances also it is required as a means for the removal of sewage and slop waters, while the provision of sheets of ornamental water adds largely to the amenity of many neighbourhoods. Deficiency of water is invariably followed by ill-health and a lowering of the moral standard, while its absence has occasioned many a tragedy on sea and land, and been the cause of war and intrigue.

Composition and Physical Properties.—Water is a chemical compound consisting of two volumes of hydrogen and one volume of oxygen. Under ordinary conditions it is a liquid which is clear, transparent, and devoid of colour, taste, and smell. When viewed in bulk, however, against a white background, it has a faint blue tinge. Fresh water freezes at 0° C. (32° F.), becoming of a lesser specific gravity, hence ice floats on water. The density of water being greatest at 4° C., water cooled below this temperature expands in volume, and so a definite quantity of water when converted into ice is of a greater bulk. In the process of freezing, the water on the surface of a pond, being cooled, increases in density until it reaches 4° C. It then sinks, a warmer layer coming to the surface, which in its turn cools and sinks. Eventually, when this process can no longer continue, the surface water is cooled below 4° C., is therefore less dense, and remaining on the surface becomes frozen. Water boils at 100° C. (212° F.) when under ordinary atmospheric pressure, the boiling point rising as the pressure increases, and diminishing as the pressure lessens. In boiling, the water becomes converted into steam, and here again expansion takes place. At all temperatures water evaporates, and the higher the temperature the more rapid the evaporation, the greater the quantity of water taken up by the air, and the greater the elastic tension of the aqueous vapour. Water is an almost universal solvent, and as a rule, in the case of solids, its power in this direction increases with a rise of temperature, the reverse being true in the case of gases at ordinary pressure. Lime forms a notable exception to the above rule regarding solids. 1 c.c. of water at 4° C. weighs 1 grm., and is taken as the unit of weight, and the amount of heat required to raise this quantity of water 1° C. is regarded as the unit of heat.

Sources of Water.—All water is primarily derived from rain, snow, hail, mist, or dew, and a constant cycle of evaporation and condensation takes place. The clouds are due to evaporation proceeding from the surface of the sea, lakes, and all humid earth surfaces, and to the discharge into the atmosphere of watery vapour, the product of combustion. When rain in any of its varied forms falls upon the earth, part evaporates, part "inclinates," and part percolates. The relative proportion in which these three processes occur depends on—(1) the atmospheric temperature; (2) the atmospheric humidity; (3) winds; (4) the nature and slope of the soil, especially its geological formation, permeability, dryness, or saturation, and the proximity of the nearest impermeable layer to the surface; (5) the vegetation; (6) whether the conditions of the receiving surface are natural or modified by human agency, as in the formation of prepared collecting surfaces.

In this country, on granite and dense rocks, 90 to 100 per cent. of the rainfall "inclinates," whereas on loose sand almost the same percentage percolates. Chalk holds an intermediate position, while some limestones permit of little percolation, the water flowing off them, and others contain cavities in which the water gradually accumulates.

The portion that evaporates helps to provide future rainfall; the second portion may form a water supply from surface waters, rivers, and streams; while the third goes to nourish vegetation and to replenish the ground water, becoming available as a water supply in the form of wells and springs.

Rain water as long as it has passed through pure air is wholesome and potable, though scarcely as palatable as certain other forms of water supply, owing to its lack of salts (softness). It is, however, highly aerated, absorbing oxygen, nitrogen, and carbonic acid from the atmosphere, but not in the same proportions as they exist in the atmosphere, since oxygen is more soluble than nitrogen. Expressed as c.c. per litre, rain water usually contains 25 c.c. of gas per litre, of which oxygen forms 8 c.c., nitrogen 16·5 c.c., and carbonic acid ·5 c.c. Further, rain water may contain ammonia, nitric and nitrous acids, sulphuric and sulphurous acids, sulphuretted hydrogen, tarry and carbonaceous matter, organic matter, pollen, microscopic plants and spores of fungi, and micro-organisms, if these are present in the atmosphere through which it falls. Rural rain water is thus much purer than that of towns. Over or near the sea, water may contain chloride of sodium, while, in addition, salts of calcium and magnesium may be present. It is obvious that the total solid matter found in rain water will vary greatly in different localities.

Snow water contains less gases than rain water, but any saline matters present in rain water will be present in it.

Surface waters consist of rain water which has washed the surface of the soil without penetrating it. Their constitution therefore depends on the nature of the surface with which they have come into contact. In high, hilly regions remote from the abodes of man, comparatively free from animal life, and where the vegetation is not excessive, they are likely to be very pure. Indeed, such upland surface waters only differ from rain water in possessing a greater amount of dissolved solids, which tend to render them more palatable, and some vegetable organic matter. Other surface waters may become extremely impure, being fouled by artificial manure, polluted by the excreta of men and animals, discoloured and rendered filthy by trade effluents and household waste. Others again take up injurious matter of a different kind, such as vegetable acids from the decomposition of peat, poisonous minerals from rocks, and deleterious substances from rotting or toxic vegetation.

River water.—This is derived from surface water, from water which has percolated, and to a much less extent directly from rain and snow water. Its composition depends on its ultimate course and the districts which it drains. Thus the water of a long river may completely change its character several times during its course, and impurities in it may even be removed. Most river waters contain a large quantity of mineral salts in solution. As the water is in motion and being constantly aerated, oxidation proceeds apace, and thus a river contaminated with sewage may in large measure purify itself, provided its course be of sufficient extent, a requisite not forthcoming in this country. The suspended matters in impure river water become deposited, and if in great excess may even help to silt up a river-bed or foul its banks.

Lake water.—This is essentially the same as upland surface water, and its natural purification is aided by sedimentation. Minerals and salts may be added by solution from rock outcrops in the bed of the lake, but the character of the water depends more on the streams which feed the lake and the immediate surroundings of the latter as regards population.

Spring and well water.—This is water which has percolated, and in its passage through the soil has absorbed much carbonic acid from the ground air. Its solvent power is thereby much increased, and it takes up various salts from the soil, such as calcium carbonate and carbonates of potassium, sodium, and magnesium, and decomposes others, such as silicates. As a rule, spring water is clear, cool, and sparkling, and agreeable to the taste, owing to the gases it contains and the filtration it has undergone. If from great depths, it may possess a considerable temperature. The location of springs depends upon geological structure, and they are classified as dip, fissure, and junction springs.

Dip springs.—These are so called because water, entering at the outcrops of permeable strata and held up by an impermeable stratum at no great depth, runs in the direction of the dip of the strata, and issues as a spring where the permeable strata are cut across, as in a river valley. By the dip of strata is meant their inclination to the horizon. Such springs are sometimes called "land" springs. They are common in sand and gravel overlying clay, are shallow, and liable to become contaminated. Further, they are apt to be intermittent in dry weather.

Fissure springs.—These are formed by water forced up through natural fissures in the ground, and are met with in granitic regions. The water percolating to great depths, is subjected to great pressure, so that, meeting a natural outlet like a fissure, it rises to the surface.

Junction springs.—These occur where water-bearing strata encounter rocks of different consistence, which are less permeable. Consequently the water rises between them till it emerges at the surface. Such springs are commonly met with at the geological formations known as "faults," which are special varieties of fissure due to displacement of strata. Junction springs may be shallow or deep, but are most frequently of the latter variety. The term "main" is sometimes applied to the deep-seated fissure and junction springs which flow all the year round, yielding a greater supply in the winter time. The temperature of spring water varies very considerably, according to its origin. In volcanic regions the water may issue at boiling point, and thermal springs occur where water heated by subterranean influences escapes at a higher temperature than that of the locality in which they are found. The water of moderately deep springs has a temperature much the same as that of the ground which it has traversed, while the water of shallow springs varies in temperature with the season.

Wells are artificial methods of tapping the ground water. They are divided into shallow or deep, the latter being those which pass through an impermeable stratum.

Shallow wells are those sunk in superficial permeable layers which are underlaid by the impermeable stratum, and which vary in depth according to its distance from the surface. As a rule they are less than 50 ft. in depth. Their water is of the same composition as that of the neighbouring shallow springs.

Deep wells tap collections of ground water which are enclosed between two impermeable strata. Their water is pure, well aerated, and free from suspended matter, though sometimes hard.

Artesian wells are a variety of deep wells so termed from having been first employed at Artois in France. They depend on a basin-shaped arrangement of pervious and impermeable strata. The well pierces the upper impermeable strata and taps the deep water-bearing strata, whose outcrops form a collecting surface often many miles from, and at a higher level than, the site of the well (Fig. 64). A good example is seen in the case of the much depleted London basin, the strata tapped being the lower London tertiaries (sand and gravel), the chalk, and the upper and lower greensands. Artesian wells may be very deep, as much as 2000 ft., and the water obtained from them is pure, though often hard and not well aerated.

Ice water.—Water in freezing becomes pure, losing some of its saline constituents and contained air, as well as some of its organic suspended matter. It is not, however, entirely freed from microbes. Ice water is unpalatable owing to its flatness, and it requires aeration.

Distilled water may be used, but also lacks air and mineral matter.

Sea water, when distilled, may be utilised as a source of water supply.

Value of these Sources.—Rain water, owing to its softness, is excellent for washing and domestic purposes. Its value as a potable water depends largely on the means taken to collect and store it (p. 331), and also on the nature of the atmosphere through which it has fallen. Urban rain water, in nearly all instances, requires purification, and, at the best, forms an uncertain source which cannot be safely relied upon: it should be avoided where other good water is obtainable. Where rain forms the source of supply for a town, very large reservoirs are required, owing to the uncertain length of the dry season, and this involves considerable expenditure. Upland surface waters, as a rule, form an excellent and palatable supply, though occasionally they require filtration to get rid of contamination or undesirable colour. They are soft and contain little chlorine; consequently are good for drinking, household, and trade purposes. Lowland surface waters must always be regarded with suspicion. River water forms a good and palatable supply, as long as it has not been fouled by sewage, trade effluents, etc. Unfortunately most rivers in this country have been rendered impure. River water is, as a rule, neither too hard nor too soft, but in its natural condition contains a fairly

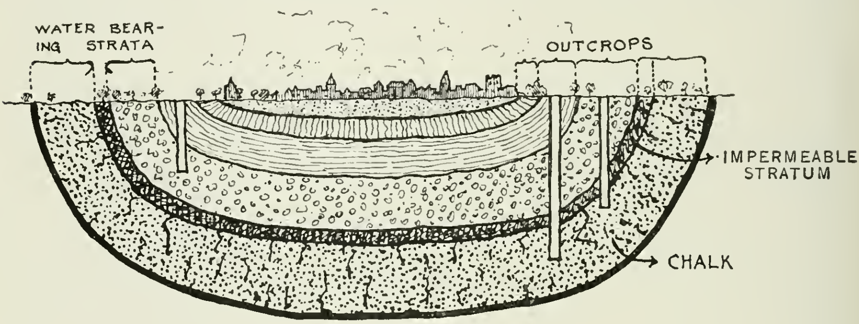


Fig. 64.

large quantity of organic matter chiefly of vegetable origin. Lake water, if unpolluted, is also very desirable. Shallow spring or well water is exceedingly liable to contamination, and though it is palatable should not be used as a water supply. If it is the only supply available, its relation to any possible source of impurity must be carefully considered, as well as the nature of the soil, the direction of the flow of the ground water, and the depression in level produced by pumping, because this influences the drainage area of the well (pp. 332, 337). The common polluting agents tend to render these waters hard and laden with micro-organisms, while they contain ammonia, chlorides, nitrites, and nitrates. They are unsuitable for domestic purposes, as they waste soap and cause deposit in household utensils in which they are boiled.

Deep spring and well waters, as a rule, form admirable supplies for drinking purposes. The danger of surface contamination, however, must not be forgotten, and engineering works are often required to render them perfectly safe (pp. 332, 337). Fissures and "swallow holes," such as occur in chalk, may conduct organic impurities into them below the level of the impermeable stratum, while they may be fouled from afar owing to organic contamination of the outcrops of permeable strata. Such waters are often hard, especially those derived from the chalk, oolitic, and magnesian limestones, and the calcareous portion of the coal measures.

The following tables, drawn up by the Rivers Pollution Commissioners, will be found useful :—

1. In respect of wholesomeness, palatability, and general fitness for drinking and cooking—

Wholesome	(1) Spring water	Very palatable.
	(2) Deep well water	
	(3) Upland surface water	Moderately palatable.
Suspicious	(4) Stored rain water	
	(5) Surface water from cultivated land	Palatable.
Dangerous	(6) River water to which sewage gains access	
	(7) Shallow well water	

2. Classified according to softness with regard to washing, cooking, etc.—

(1) Rain water.
(2) Upland surface water.
(3) Surface water from cultivated land.
(4) Polluted river waters.
(5) Spring waters.
(6) Deep well waters.
(7) Shallow well waters.

3. As regards the influence of geological formation in rendering the water sparkling, colourless, palatable, and wholesome. The following water-bearing strata are the most efficient—

(1) Chalk.
(2) Oolite.
(3) Greensand.
(4) Hasting's sand.
(5) New red and conglomerate sandstone.

Characteristics of a Good Potable Water.—A good drinking-water must be clear, cool, colourless, odourless, palatable, moderately aerated, and possess a neutral reaction and no visible sediment. Its dissolved solids should not exceed 10 parts per 100,000, its total hardness should not exceed 6°, *i.e.* 6 grs. per gallon, its fixed hardness 2 grs. per gallon. (These figures correspond respectively to 8·5 and 2·8 parts per 100,000.) The free ammonia should be under ·002 parts per 100,000, and the albuminoid ammonia under ·005 parts per 100,000 ; there should be no nitrites or nitrates, and the chlorine should be below 1·5 parts per 100,000. The oxygen required for the oxidation of organic matter should be under ·1 per 100,000, there should be no sulphides or metals present, and the number of micro-organisms should not exceed 100 in 1 c.c., and none of them should be pathogenetic. This gives a general idea of the conditions a water should fulfil if it is to be regarded as a first-class supply.

Search for Water.—A study of the geological formation of a district is the best guide to the places where water is likely to be found. Attention must be directed to faults, fissures, junction of strata, and the direction of impermeable strata. Vegetation, especially herbage, often gives a clue, as where the latter is abundant water is usually found not far from the surface. Water is often readily forthcoming near the sea, but may be brackish or become so after being exposed to a wind driving sea salt into it. The pressure of water in high land near the sea may be sufficient to prevent the supply becoming brackish by checking percolation from the sea. At the junction of valleys and the bases of hills, water is likely to be found near the surface. The supply must not be judged from the amount immediately available in sinking a well, as the nature of the soil, the season of the year, the prevailing weather conditions, the general surroundings, and the effect produced by pumping, have all to be taken into account. Norton's tube wells have often proved useful in the quest for water (p. 337). A popular method in searching for water is the use of the "divining rod" or "dowsing stick," the rationale of which is perhaps more scientifically based on the above considerations than is generally supposed.

Amount of Water required.—Water is necessary for drinking purposes, for personal cleanliness, for washing clothes, utensils, houses, streets, etc., for cooking, for sewage disposal, for animals, for fire extinction, for trade purposes, for public baths, wash-houses, and conveniences, for fountains, and it may be for other ornamental waters. Waste has in all instances to be taken into account. The amount necessary varies with the area of the inhabited district, the number, social class, and habits of the population, the industrial pursuits of the inhabitants, and the system of drainage. It is usually stated in gallons per head per day, and should roughly average 30 gals. per day for adults, and half that amount for children, this allowing a fair margin for waste.

The following table gives a liberal average :—

		Gallons per head per day.
Household	Drinking-water	·5
	Cooking	1
	Personal cleanliness	5
	General baths	4
	Utensils and house washing	3
	Clothes washing (laundry)	3
	Water closets	6
Municipal	Cleansing streets	1
	Flushing and cleansing sewers and public conveniences	2
	Fire extinction	1
	Public baths, wash-houses, and fountains	2
	Trades and manufactures	5
	Waste	3
	Total	36·5

No allowance for animals is here made, 16 gals. being required by each horse, and 10 gals. for each cow. In the case of drinking-water the amount used varies much with age, sex, weight, climate, and occupation. Women drink less than men, and children also less, but relatively more considering their size. Nine gals. per head per day for personal ablution will allow either a daily sponge bath or weekly tub per person. The presence or absence of water-closets is the main determining factor as to the amount to be supplied to any town, towns with the conservancy system of sewage requiring much less water than those served by the water carriage method. Certain trades use up exceptionally large quantities of water, *e.g.* gelatine manufactories and breweries. The latter, however, prefer hard water, and frequently possess special private supplies from wells, etc. Waste ought to be better controlled than is at present the case, being due to faulty water mains, taps, and fittings, and carelessness on the part of consumers. Hospitals require a specially large quantity of water, especially if balneo-therapy be practised.

Supply.—Water may be supplied either constantly or intermittently, and these systems will be found fully discussed under the section of Hydraulic Engineering (p. 350).

Impurities in Water.—From what has been said it will be apparent that these may be of an inorganic or an organic nature.

Inorganic.—These are chiefly derived from the minerals forming the rocks with which the water is in contact. Thus from chalks and limestones water obtains those salts which tend to render it hard, namely, calcium carbonate, causing temporary hardness removable by boiling, and calcium sulphate producing permanent hardness. Hardness is also due, in some measure, to salts of magnesium, chlorides, nitrates, silicates, alumina, and iron. The magnesium salts are yielded by the dolomites; chlorides frequently by the sea, rock-salt deposits, and sewage, especially urine; silicates by soil washings in volcanic regions, and the débris of granitic rocks; iron by peaty soils and the chalybeate rocks. Further, some soils contain nitrates of potash, soda, and magnesium, which may be dissolved out by the water, while certain waters owe their alkalinity to potassium and sodium carbonate. Sulphides may gain access to water in volcanic regions, and the solution of lead, zinc, arsenic, copper, and manganese from metalliferous strata is not unknown. Minute quantities of fluorine, bromine, and iodine may be derived from the soil. Apart from these soil constituents, water may take up metals, the most important of which is lead, derived, as a rule, from leaden pipes or cisterns. Certain waters act more on lead than others. These are—(1) those containing organic matter; (2) peaty waters containing a free acid; (3) those containing chlorides; (4) those containing most oxygen; (5) water containing free acid, such as excess of carbonic acid. The first variety is exemplified by waters contaminated with sewage. It has been found that the liquid mud of the Thames is so impregnated with organic matter, that it can dissolve the lead present in the piers of bridges, while the classical cases of lead poisoning which occurred at Claremont during its occupation by the exiled Royal House of France were due to a water which owed its lead-absorbing power to its having been fouled by the drainage from a midden heap. Soft peaty waters containing the products of the decomposition of peat, as is commonly the case in autumn, frequently exhibit an acid reaction, due to the presence of an organic acid of the fatty series, which, as proved by Houston, is the product of micro-organismal action. This acid has a powerful solvent effect on lead. When moorland water has an acidity that reaches ·5 parts per 100,000, it is dangerous on account of its lead-dissolving powers, the quantity of lead dissolved increasing with each rise of acidity above ·5. Below this amount lead is not dissolved in sufficient quantity to produce toxic symptoms when the water is drunk. A protective layer of carbonate of lead often forms in leaden water pipes, but if chloride be present in the water this layer is apt to be dissolved and the surface of the metal exposed. Rain water and soft upland waters contain much oxygen, and in virtue of this have a solvent action on lead, an oxide of the metal being formed which may exist as a suspension or is dissolved, especially if the water be at all acid. Any acid in water renders it capable of acting on lead. Thus a water containing acid sulphates is dangerous, while excess of carbonic acid, as met with in aerated waters, constitutes a risk. An alkaline water does not generally act on lead, but it must be noted that a water containing free and combined carbonic acid, such as deep well water, may have an alkaline reaction and yet be capable of acting on lead. Thus, in testing the action of a water on lead, it is important to retain the carbonic acid present in the water, otherwise a false impression may be given. Water acts on lead in two ways—(*a*) plumbo-solvent; (*b*) plumbo-erosive. In the latter an insoluble oxycarbonate of lead is formed, but it does not act as a protective crust, being of a powdery nature, and is thus carried off in suspension. It consists of two parts of lead carbonate and one part of hydrated oxide. The same water may have both actions.

The waters which act least on lead are—(1) hard waters; (2) those containing free carbonic acid, if it be not in excess; (3) those containing silica. Deep well water is an example of the first variety, except when sulphates are in excess. Carbonate of lime especially tends to form an insoluble protective adherent crust in leaden pipes and cisterns. Free carbonic acid, if not in excess, acts in a similar way, forming a basic carbonate of lead. Silica in water forms with lead an insoluble lead silicate, consequently waters containing much silica are believed not to act readily on lead, though there are exceptions to this rule. The usual crust formed on leaden pipes when the water is hard, consists of carbonate, phosphate, and sulphate of lead, calcium, and magnesium, with some chloride of lead. In point of efficacy, calcic carbonate is superior to calcic sulphate, and both to the magnesium salts.

Accessory influences affecting lead absorption by water—(1) The age of leaden pipes or cisterns; (2) the period of contact; (3) the temperature of the water; (4) the pressure in the pipes; (5) the bending of pipes against the grain; (6) the juxtaposition of lead with other metals; (7) the use of zinc pipes; (8) the alternate filling and emptying of pipes; (9) the purity of the lead employed.

New lead pipes yield more lead to water than do old ones, while the time the water stands in pipes increases the quantity of lead dissolved, so long as no protective coating is formed. Hot water has a greater action than cold water, and water under pressure than water free from it. The juxtaposition of metals, such as lead with iron, zinc, or tin, results in galvanic action and consequent increased absorption of lead. Zinc pipes are dangerous owing to the quantity of lead they usually contain. No water should be used for drinking purposes which contains more than $\frac{1}{20}$ gr. per gallon, or ·07 parts per 100,000. Any trace of lead, however, should cause a water to be viewed with suspicion, because idiosyncrasy to its ill effects exists, and further, the amount present at one time may not represent the maximum.

The prevention of lead poisoning due to drinking-water resolves itself into—(1) treatment of the water; (2) attention to the means of distribution; (3) failing these, care in use.

The treatment of water on a large scale is dealt with on p. 347, while the devices employed to obviate the risk from pipes are mentioned on p. 333. The third point refers to the plan of allowing the water to run from the taps for some time before use, and to filtration, pp. 334, 346. Rain water may take up lead or zinc from flat roofs used as collecting surfaces.

Organic.—These may enter water at its source, during its transit, or in its distribution, and may be dissolved or suspended. Many vegetable impurities, which are as a rule harmless, may be found. The most important impurity is, however, sewage, and this chiefly because it may be the means of introducing pathogenetic micro-organisms. River water is thus frequently contaminated, and wells may become infected from privy middens, cesspools, sewers, drains, foul ditches, and sewage farms. The drainage from a grave-yard may pollute a water supply, and water receiving such impurity is often peculiarly bright and sparkling, containing nitrites and nitrates, products of the oxidation of ammonia, fatty acids, and much animal organic matter. Dead animals, such as birds and mice, often fall into cistern water; while in water collected on roofs, soot and bird droppings are frequent sources of pollution. Manufacturing refuse is very frequently of an organic nature, and its effect on fish life is important. For example, distillery effluents cause the growth of a fungus, the *Leptomitus lacteus*, allied to the salmon fungus, which blocks up streams, and has been the cause of much litigation. Such trade refuse is most commonly a nuisance or danger in connection with river waters. Low forms of vegetable and animal life are present in all natural waters, and the great majority of these are innocuous, while many are beneficial, being antagonistic to pathogenetic forms, and greatly aiding the oxidation of organic matter. Coal-gas may gain access to wells and water pipes, owing to leaks in underground gas pipes.

WATER AND DISEASE.

Apart from the general, specific, and toxic diseases produced in individuals from drinking impure water, and considered under the section devoted to Medicine, and on p. 124, the mere deficiency in the supply of water to a community may result in a general lowering of the physical, mental, and moral tone of the inhabitants, is apt to favour the spread of epidemic disease, and lead to nuisances in the shape of dirty persons, clothes, houses, streets; choked sewers, and air fouled by emanations. Examples of outbreaks of characteristically water-borne epidemics of specific disease are here given to illustrate what has already been said concerning them.

Cholera.—To exemplify a river-spread epidemic, that at Hamburg in 1892 may be taken. Hamburg obtained its water supply from the unfiltered water of the Elbe above the town; Altona, a closely adjoining community, from the Elbe below the town, but the water was filtered; Wandsbeck, also adjacent, from a lake, the supply being filtered. In all other important respects the three places were alike, and yet cholera was entirely confined to Hamburg. As an example of an epidemic due to drinking well water, the London outbreak of 1854 may be cited. It was limited to the consumers of water drawn from a well found to be polluted with sewage.

Dysentery.—In the early part of 1901, at Kaapsche Hoop, in the Eastern Transvaal, it was found that in three bodies of troops occupying different camps, namely, the 4th Mounted Infantry, the Liverpools, and the Royal Scots, men suffered from a mild form of dysentery. All these detachments obtained their water from a well into which the slope of the ground permitted the drainage from badly placed latrines to flow. The men of a pom-pom section, otherwise under exactly the same conditions as these troops, drew their water from another source, as did the people inhabiting several Dutch laagers and a gold mining village. No cases of dysentery were encountered amongst the artillery, the Boers, or the villagers.

Enteric Fever.—A good example of an enteric outbreak spread from polluted river water is that which scourged our troops in South Africa, and which was due, in the first instance, to the imbibition of the infected water of the Modder and Riet rivers. The epidemic in the Tees valley, following a flood which scoured a foreshore fouled from privy middens, may also be instanced. Darlington, Stockton, and Middlesborough received their water supply from the river Tees, into which the drainage of Barnard Castle and several villages had access above these towns. Adjacent districts which obtained their water supply elsewhere suffered very little compared with those dependent on Tees water. Maidstone forms a recent example of an epidemic resulting from the use of infected spring water, while the outbreak at Newport in the Isle of Wight demonstrates a distribution of the disease by the agency of well water.

Malaria.—Much controversy has arisen over the possibility of the transmission of malaria by drinking-water. Recent discoveries, however, probably supply the clue. A severe outbreak of the fever occurred on board ship, and it was found that all those attacked had drunk water derived from a marsh, while those who had drunk pure water were exempt. It is probable that the marshy water contained plasmodia liberated from the dead bodies of the mosquitoes, and that the parasites passed through the stomach walls into the circulatory systems of those affected.

Characteristics of Water-borne Epidemics.—Epidemics spread by water have the following points in common :—(1) Abbreviation of the incubation period. (2) Sudden and localised outbreak. (3) High attack rate. (4) Low case mortality. (5) Simultaneous cases in the same house ; characteristic, if at the first invasion of the household. (6) Difficulty in isolating the specific microbe.

Purification of Water.—*Vide* pp. 334, 344–348.

Examination of Water.—In examining a water, the sample has to be carefully collected, and the water itself has to be tested as to its physical properties, its qualitative and quantitative chemical constitution, its suspended matter, and its contained micro-organisms.

Collection of Sample.—From a stream, lake, spring, or well the water should be collected in large, clean glass vessels, such as Winchester quart bottles, which hold half a gallon, and which should be washed out several times with some of the water of which a sample is going to be taken. The thing to be avoided is the inclusion of surface water, and this is best done by sinking a bottle in a basket jacket, and having an arrangement whereby the bottle plug is removed after submersion. The bottle is then fitted with a glass stopper, a cork being inadmissible, while no luting must be used. For complete analysis a considerable quantity is required, and for this purpose, as well as to provide against loss by accident, it is customary to take not less than one gallon. The samples should be collected at a time when the water is under its normal conditions, and the bottles should not be sunk close to the water margin, while the act should be done gently so as not to stir up sediment. In the case of the Maidstone springs, when searching for the enteric bacillus, it was found that positive results could only be obtained when the sample was collected over a prolonged period, thus ensuring the sampling of a much larger quantity of water. In collecting from a pipe, the tap should be allowed to run for a time before the specimen is taken, to prevent impurities in the pipe being collected in the sample. If a bacteriological analysis is to be conducted, the nozzle should be flamed and then cooled by the running water before the bottle is filled. After stoppering, the bottle should be carefully labelled with the source, date, time of collection, and temperature of the water. The examination should be made as soon as possible, since the composition of a water is very apt to change, especially in hot weather. It is therefore desirable that prompt and speedy transit to the laboratory be provided, and the bottles should be kept in a cool, dark place. A proper interpretation of the results of the analysis cannot be made without a knowledge of certain particulars—

(1) The source of the supply, both immediate and remote. (2) The possibilities of contamination. (3) The geological features of the locality, inasmuch as they influence the supply. (4) The prevailing and recent meteorological conditions. (5) The presence of any disease in the locality which may be water-borne.

Physical Examination.—Clarity.—To determine the clearness, shake up any sediment, and view the water in a tall glass against a white background. A test of turbidity is the extent to which printed matter is obscured when read through the water.

Temperature.—This should be taken with a view to the subsequent chemical and biological examination.

Colour.—The colour is decided after any sediment has been allowed to deposit, the supernatant fluid being poured into a tall glass tube placed on white paper. The water should stand at a depth of 2 ft. in the tube, and the colour, judged by looking down through the column, is compared with that of a similar column of distilled water placed alongside it in the same light. A slight blue or grey coloration may be present in a pure water, but a brown or yellow colour should excite suspicion, though it may only be due to peat or iron. More commonly, however, it indicates sewage contamination. A greenish colour is generally due to the presence of harmless algæ.

Smell.—This should be determined before the sample has been exposed for any time to the air, and by one who has been in the fresh air immediately beforehand. Pure water has no smell, but the absence of odour is no criterion of the purity of a water. A water which when fresh drawn has no smell, may acquire an odour on keeping, due to putrefactive changes. To thoroughly test the smell, the water should be warmed, boiled, or distilled, by which means odours which may have been imperceptible will be apparent, and should be noted according to their character and degree of intensity.

Taste.—A good water should be palatable owing to its contained gases. A water with a bad taste ought to be condemned, or purified before use. The only substance which in minute quantities will give a taste to water is iron; but if in excess, various salts, such as the chlorides and those which confer hardness, will do so. Plants growing in water do not, as a rule, yield any taste to it, but some render it bitter. Stagnant waters and those impregnated with animal organic matter frequently possess an unpleasant taste.

Sediment.—Gross deposits can be detected by the unaided eye, but in all cases microscopical examination is required, special attention being directed to the presence of vegetable fibres, hair, and epithelium, which indicate organic pollution. A physical examination when unsupported by analysis is not of great value unless a water is grossly impure, but it should never be neglected.

Chemical Examination.—Qualitative.—*Reaction.*—This is tested by means of litmus or turmeric paper. An acid reaction which vanishes on boiling is due to carbonic acid; and an alkaline reaction which behaves in the same way owes its existence to ammonia. A good potable water should have a neutral reaction.

Lime is tested for by a solution of oxalate of ammonium, with which it gives a white precipitate when present to the extent of over 20 parts per 100,000; 8 to 10 parts per 100,000 cause turbidity on addition of the reagent. If, after boiling, the lime reaction is still forthcoming, calcium is present in the form of sulphate, chloride, or nitrate; but if boiling prevents the reaction, the carbonate has been present.

Magnesia.—In testing for magnesia salts, the water has to be concentrated by evaporation in a porcelain dish, then the lime has to be precipitated with oxalate of ammonium, and the precipitate removed by filtration. To the filtrate is added a little phosphate of sodium and chloride of ammonium with excess of ammonia. It is allowed to stand all night, when a white crystalline precipitate of triple phosphate (ammonium-magnesium phosphate) is obtained. A strong magnesia reaction, together with indications of considerable chlorine and very little organic matter, suggest the access of sea water to the supply. Magnesia with a considerable amount of organic matter and no excess of chlorides, may point to a magnesian limestone formation as a source of the water, such formations frequently containing marshes.

Chlorides.—They are tested for as chlorine by means of silver nitrate, a white precipitate of silver chloride being formed when chlorine reaches 15 parts per 100,000. Smaller quantities produce a cloudiness or turbidity. A large quantity of chlorine in water may owe its origin to sea water, certain geological strata, or contamination with sewage, especially urine. The organic matter present affords a guide to the real source, much being present if sewage be the cause, and little if sea water or strata are to blame.

Ammonia.—Nessler's solution, a saturated solution of mercuric iodide in potassic iodide, gives a yellow colour.

Nitrous acid.—A solution of metaphenylene-diamine and dilute sulphuric acid gives a yellow or brown colour, which constitutes a very delicate test. This colour is due to the conversion of metaphenylene-diamine or meta-diamido-benzole into meta-triamido-benzole or Bismarck-brown. Potassium iodide and starch along with dilute sulphuric acid strike blue.

Nitric acid.—Evaporate down 2 c.c. of the water, and add to the dry residue a drop of pure sulphuric acid and a crystal of brucine. A pink and yellow tint results. This test is unreliable in the presence of nitrous acid. A strong indication of sewage pollution is given when, along with much chlorine, ammonia, nitrous acid, and nitric acid are present with phosphoric acid and oxidisable organic matter. The more recent the contamination, the greater the quantity of the last-named and of ammonia and nitrites. If derived from strata containing chlorides, the water is also often alkaline from sodium carbonate, and may possess sulphates. *Example.*—Deep well water.

If ammonia be present in such quantities as to give a qualitative test without distillation, the water is very bad. Nitrites and nitrates are frequently merely different stages in the oxidation of ammonia present from sewage contamination. Nitrites may be changed by oxidation, with or without the aid of bacteria, into nitrates, while bacterial action may alter nitrates into nitrites. More rarely nitrates may be the result of vegetable pollution, or may be derived from impure soil, as from grave-yards. If nitric acid be present without nitrites or ammonia, and occur in the form of its potash, soda, and lime salts, the water is probably derived from strata long ago fouled by animal organic matter, for example, fossil-bearing rocks.

Sulphuric acid.—Chloride of barium and dilute hydrochloric acid give a white precipitate, immediately if the sulphuric acid exceeds 4 parts per 100,000, and after a time if in smaller quantity. Sulphuric acid in large quantities is usually associated with lime, otherwise it is combined with soda, and accompanies the chloride and carbonate of that base, which render the water alkaline. It may be due to trade effluents.

Sulphuretted hydrogen.—A black precipitate is formed with one of the lead salts (of which the best are the acetate and the hydrate) and caustic soda. Sulphuretted hydrogen may show that the water is derived from volcanic regions and the neighbourhood of sulphur deposits. More commonly it comes from manufactories or gas works as a preventible pollution.

Phosphoric acid.—In a concentrated water the addition of dilute nitric acid and molybdate of ammonium gives a yellow colour, and later a precipitate. Phosphoric acid, as a rule, may be taken to indicate sewage contamination.

Silicic acid.—In a water evaporated to dryness, silica alone remains when hydrochloric acid has been added and the residue has been washed, dried, and ignited.

Iron.—Prussian blue is formed on treatment with the red or yellow prussiates of potash and dilute hydrochloric acid, the ferrous salts reacting with the red, and the ferric with the yellow prussiate. Iron is the solitary metal which does not necessitate condemnation of the water.

Lead.—Small crystals of bichromate of potash thrown into the water leave a yellow trail behind them as they sink, and give a turbidity even with $\frac{1}{50}$ gr. per gallon if half an hour is allowed to elapse. Ammonium sulphide gives a brown or black colour which is not discharged with hydrochloric acid, as is the case with iron.

Copper.—The ammonium sulphide test holds good for copper as for lead.

Zinc.—Add ammonia, boil, filter, and the filtrate gives a white precipitate with ferrocyanide of potash.

Arsenic is indicated by Marsh's or Reinsch's test in the residue after evaporation, sodium carbonate having been added before evaporation, and hydrochloric acid after it.

Oxidisable matter including organic matter. Its presence is shown by the decolorisation of permanganate of potash solution; and, secondly, by slightly acidulating the water and boiling it with a few drops of solution of gold chloride for twenty minutes. A colour varying from violet to black is produced, according to the amount present. Some of the reaction may be due to nitrous acid.

Quantitative Examination.—As before, the mere rationale of the processes is given as briefly as is consistent with an intelligible exposition of the subject.

Solids.—Solids in water are estimated by evaporation of the water and weighing of the residue in a tared vessel. They are expressed as grains per gallon or parts per 100,000. The loss in weight after ignition of the residue represents the solids capable of volatilisation by combustion.

Hardness.—In addition to what has been stated (p. 189), it must be remembered that carbonic acid, either free or holding calcium carbonate in solution as the bicarbonate, may play a part in making a water hard. The best test for hardness is that with a soap solution (Clark's). A soap is a combination of an alkali with a fatty acid, the alkaline base being soda, potash, or ammonia if the soap is soluble, and one of the alkaline earths if insoluble. The fatty acids are oleic, palmitic, stearic, and margaric. Soft soap has potash for its base, while the ordinary harder soaps have soda. A soap has the property of producing a lather with a pure water, but if the water contain the salts which render it hard, no lather can be obtained until all the lime, magnesia, etc., present have combined with soap. According to the quantity of soap used before a permanent lather can be formed, the amount of hardness is measured. For this purpose a standard soap solution, of which 1 c.c. precipitates 1 mgrm. of calcium carbonate, is used. The total hardness is first estimated, then the water is boiled, filtered, and the permanent hardness remaining is tested. The difference gives the temporary hardness due to the calcium carbonate held in solution by the carbonic acid and precipitated, the carbonic acid having been driven off by the boiling. Hardness is stated in degrees, one degree in Clark's scale corresponding to 1 gr. per gallon. It may also be expressed as parts per 100,000. In a water containing both lime and magnesia, the lime soap is formed first and then the magnesia soap, so that a lather may occur and then disappear, thus causing a difficulty in observation. It takes more soap to form a lather with magnesia than with lime.

Chlorides.—The fact that chloride of silver is more insoluble than chromate of silver is taken advantage of to provide a quantitative test for chlorides. A standard solution of silver nitrate is required, of which 1 c.c. = 1 mgrm. of chlorine. This solution is run into the water from a burette, and potassium chromate is used as a colour indicator, a permanent red colour appearing as soon as all the chlorine is combined with silver and the silver chromate begins to form. The number of c.c. of silver nitrate solution used represent an equal number of mgrms. chlorine present in the sample. Chlorides are expressed in parts per 100,000.

Phosphates are not usually estimated quantitatively, but their presence is stated as being a more or less distinct trace. If a more definite result is desired, they may be estimated gravimetrically after precipitation with ammonium molybdate, a large quantity of water being treated.

Ammonia is estimated as free and albuminoid ammonia. The significance of these terms has been explained on p. 164. The quantity of free ammonia is determined by distillation of a known quantity of the water in a purified retort connected with a condenser, also free from ammonia, and collecting the distillate. To certain quantities of this distillate Nessler's solution is added, and the yellow colour obtained is compared with that got on treating equal quantities of distilled water with Nessler's solution after so much of a standard solution of ammonium chloride has been added to them.

The strength of the standard solution usually employed is 1 c.c. = ·01 mgrm. ammonia. The amount of the ammonium chloride which has to be added to the distilled water, in order, along with Nessler's solution, to strike a colour equivalent to that given with Nessler by the distillate, is noted, and thus the amount of free ammonia present in the example is calculated. Free ammonia is stated in parts per 100,000.

Albuminoid ammonia is determined by Wanklyn's process after the free ammonia has been estimated. To the water remaining in the retort a certain amount of an alkaline solution of potassium permanganate is added, and heat again applied. The albuminoid ammonia now comes over in the same way as the free ammonia, the distillate is Nesslerised, and the albuminoid ammonia which it contains estimated in a similar manner to free ammonia, like which it may be expressed in parts per 100,000.

Nitrites may be determined according to Griess' method, by comparison of the colour produced by the sample and by an equal quantity of distilled water plus a certain amount of standard nitrite of potassium solution, when a dilute acid and metaphenylene-diamine solution are added to both. The strength of the standard solution being known, the amount of nitrite in the quantity required to give the same colour as the sample water is easily calculated, and thus the quantity of nitrite in the water is known. This may be stated as nitrite in parts per 100,000, or may be expressed as nitrous acid in parts per 100,000.

Ilosvay's test is precisely similar to the above, except that, instead of metaphenylene-diamine, sulphanilic acid and naphthylamine are used, and the acid employed is acetic acid. The colour produced is rose-pink. The test is extremely delicate and not so useful as that of Griess.

Nitrates.—These may be estimated—(1) By the Schulze-Tiemann process, in which nitrites and nitrates are determined together and the quantity of the former, which has been calculated by Griess' test, is deducted. The method depends on the formation of nitric oxide gas produced when water containing nitrate is boiled with hydrochloric acid and ferrous chloride.

$$6\ FeCl_2 + 6\ HCl + 2\ HNO_3 = 3\ Fe_2Cl_6 + 4\ H_2O + 2\ NO.$$

The nitric oxide gas is measured in a burette, and corrected for temperature and pressure. Then each c.c. of the gas is equivalent to 2·418 mgrms. of N_2O_5.

An answer is thus got which represents the nitrates and nitrites in the water expressed in terms of anhydrous nitric acid. In order to eliminate the nitrites and estimate the nitrates only, it is necessary to deduct from the c.c. of nitric oxide gas the proportion due to nitrites in the water. This is done by calculating the number of c.c. of nitric oxide gas equivalent to the nitrites in the water: 1 c.c. of nitric oxide gas is equivalent to 3·81 mgrms. of nitrite. The quantity of nitrite in the water being determined by Griess' test in mgrms., the corresponding quantity of nitric oxide gas is known. This has to be deducted from the c.c. of nitric oxide gas calculated by the method described for nitrates, and the remainder multiplied by 2·418. The nitrates in the water are thus obtained, expressed as anhydrous nitric acid.

(2) By the phenol-sulphuric acid method. This consists in evaporating the water sample to dryness, adding phenol-sulphuric acid, washing the residue thus treated into a Nesslerising glass, and comparing the colour with a standard solution of potassium nitrate similarly treated. The standard solution is one of which 1 c.c. is equivalent to ·1 mgrm. of nitrogen.

Having found the nitrates in terms of nitrogen, they have then to be stated as anhydrous nitric acid. The result in nitrogen must be multiplied by 3·9 to convert it into terms of anhydrous nitric acid.

(3) Indigo method. Concentrated sulphuric acid, free from all trace of nitric acid, and a standard solution of indigo are added to the water sample. The sulphuric acid decomposes any nitrates present, setting free nitric acid, which oxidises and decolorises the indigo solution. From the amount of indigo thus acted upon the quantity of nitrogen present as nitrates is calculated and stated in parts per 100,000 : 1 c.c. of the standard indigo solution is equivalent to ·000086 of a grm. of nitrogen. The heat generated by the addition of the sulphuric acid to the water aids the process of oxidation, and the test should therefore be conducted rapidly.

Organic Matter in water may be estimated by five different methods—

(1) From the ammonia determination, both free and albuminoid (p. 197); (2) from the amount of oxygen required to oxidise it; (3) from the amounts of carbonic acid and nitrogen gases produced on combustion of the organic matter; (4) from the amount of nitrogen in the ammonia produced from the organic matter by sulphuric acid and heat; (5) from the amounts of carbonic acid and of nitrogen in the ammonia produced in the same manner as in (4).

It is not possible to estimate the total organic matter as such, but its amount is indicated by the determination of one or other of these products, the quantity of which forms a rough index of the amount of organic matter present.

Oxygen process.—(1) Tidy's modification of the Forchhammer method is the one usually employed. It consists in using a solution of potassium permanganate, of which every 10 c.c. is capable of yielding 1 mgrm. of oxygen to oxidisable matter.

The water under examination and a control sample of distilled water are mixed with this permanganate solution and a little dilute sulphuric acid which liberates oxygen from the permanganate. The permanganate solution is changed in colour if any organic matter is present.

The oxygen consumed is estimated, after allowing contact to proceed for a varying period of time, both at room temperature and at 80° F.

The calculation of the oxygen consumed is somewhat complicated, but may be conceived by regarding iodine as the equivalent of potassium permanganate, sodium thiosulphate, and oxygen respectively.

The test and control samples have a solution of iodide of potassium added to them, and the permanganate in the presence of acid acts on this, liberating iodine.

$$4\ KMnO_4 + 16\ H_2SO_4 + 20\ KI = 4\ MnSO_4 + 12\ K_2SO_4 + 16\ H_2O + 10\ I_2.$$

The iodine released is equivalent to the oxygen of the permanganate which is unconsumed by the organic matter. Thiosulphate of sodium is added to both samples, and the iodine combines with it, forming iodide of sodium and tetrathionate of sodium.

$$I_2 + 2\ Na_2S_2O_3 = Na_2S_4O_6 + 2\ NaI.$$

The more $KMnO_4$ is left unconsumed, the greater will be the iodine given off, and therefore the greater will be the amount of thiosulphate required to combine with it. The control sample will thus liberate more iodine and require more thiosulphate than the test sample; the difference between them will represent the lessened quantity of iodine given off by the test sample, and since iodine is equivalent to oxygen, this amount also represents the oxygen consumed.

The thiosulphate solution must have a definite strength, *i.e.* its oxygen equivalent must be known. The solution used is one in which 40 c.c. = 1 mgrm. O.

This thiosulphate solution is added until all the iodine liberated from the KI has combined with the thiosulphate, and a sharp indication of this stage is given by the addition of a small quantity of starch solution with which any uncombined iodine strikes blue.

The quantity of thiosulphate solution required for the control sample may be taken as the equivalent of 1 mgrm. of oxygen, and the quantity of oxygen represented by the difference between the thiosulphate used by the test and control samples is found from this by simple proportion.

The mgrms. of oxygen thus found represent the oxygen consumed by organic matter in the sample, and the result is expressed as parts per 100,000.

(2) *Kubel's method.*—This consists in estimating the oxygen consumed, the samples being raised to the boiling point, and the unconsumed permanganate at once titrated with oxalic acid solution, which discharges its colour. The oxidising agents are the same as in Tidy's process. The oxalic acid solution used is one of which 1 c.c. is equivalent to ·08 mgrm. of oxygen.

By preliminary experiment with distilled water, the quantity of this oxalic solution which is equivalent to the permanganate of potash solution about to be added to the test sample, is ascertained.

The permanganate added to the test sample is expressed as its equivalent of oxalic acid, and from this is deducted the amount of oxalic acid used in the later titration of the sample. The number of c.c. thus obtained multiplied by ·08 gives the mgrms. of oxygen consumed by the organic matter, and, as before, this is expressed in parts per 100,000.

(3) By the combustion process (Frankland) the organic matter in water is estimated by volumetric computation of the gases evolved, all the organic carbon being converted into CO_2, and the organic nitrogen collected as nitrogen gas. To the water strong sulphurous acid and a solution of a ferrous salt are first added with the object of liberating CO_2 from the carbonates and of reducing oxidised nitrogen. A litre of the water is then evaporated to dryness, and the residue mixed with a definite quantity of cuprous oxide. This mixture is then put into a combustion tube, and is flanked on either side by pure cuprous oxide, while a piece of copper spiral is so placed that the products of combustion have to pass over it.

The tube is heated in a combustion furnace, and the gases evolved are collected over mercury and measured, the copper spiral reducing to nitrogen any nitric oxide that may be given off. The combined volume of CO_2 and nitrogen is first estimated, then the CO_2 is absorbed by means of caustic potash, and the residue again measured and regarded as nitrogen. Every litre of CO_2 gas represents about ·5 grm. of carbon. The relative quantities of carbon and nitrogen present can be compared by this method.

(4) *Kjeldahl's method.*—The water to be examined, after acidulation with weak acid, is concentrated by evaporation, and then the process of combustion with strong sulphuric acid (as described under Soil, p. 174) is carried out. The ammonia distilled off must be estimated by Nesslerisation, and not by collection in acid and titration.

(5) Professor Hunter Stewart's method, is applicable to water as to soil (p. 175).

Iron is estimated by comparing the colour produced in the water under examination on the addition of ammonic sulphide with that produced in distilled water to which a standard solution of crystallised ferrous sulphate and some of the same sulphide solution have been added. The standard solution is such that 1 c.c. is equivalent to ·1 mgrm. of iron. The comparison is made in Nessler glasses.

Lead is determined in the same way as iron, but the water should be acidulated. The standard solution employed is such that each c.c. is equivalent to ·1 mgrm. of lead.

Copper is also estimated in a similar manner, the standard solution being such that each c.c. is equivalent to ·1 mgrm. of copper.

Gases.—Water always contains oxygen, nitrogen, and carbonic acid. The amounts of these gases present depend upon—

(1) The source of the water ; (2) the temperature of the water ; (3) the facilities for aeration of the water ; (4) the purity or impurity of the water ; (5) the nature of the gas ; (6) the pressure which the gas under consideration is exerting ; (7) the presence or absence of aquatic vegetation.

Chalk and limestone waters are apt to contain excess of carbonic acid. The higher the temperature of the water, the less, as a rule, is the quantity of dissolved gases. A water which has been brought freely into contact with air, as in falling over weirs, etc., contains more gas than a still water, and is consequently more palatable. The question of water purity or impurity has more to do with the nature of the gas than with the quantity present. The solubility of oxygen being twice that of nitrogen, and the proportion of nitrogen in the air being four times that of oxygen, a pure water should absorb from the atmosphere 2 volumes of nitrogen to 1 of oxygen. Pure waters, however, usually contain 2·3 of nitrogen to 1 of oxygen, while in impure waters the proportion may be 3 or 3·5 of nitrogen to 1 of oxygen. This is due to the using up of oxygen for the oxidation of organic matter.

Carbonic acid exists in water as carbonates, bicarbonates, and as dissolved gas ; in the two latter forms the carbonic acid can be driven off by boiling the water.

One litre of water can absorb either 30 c.c. of oxygen or 15 c.c. of nitrogen, or 1000 c.c. of carbonic acid at 15° C. and 760 mm.

The higher the pressure which the gas in contact with water exerts, the more of it is dissolved.

The effect of aquatic vegetation on the gaseous condition of a water varies with the variety of the vegetation, which, as a rule, has a beneficial action, oxygen being yielded to the water. Other gases, such as sulphuretted hydrogen, marsh gas, and ammonia, may be found in water, the presence of marsh gas often indicating fouling with coal-gas. Organic matter may reduce sulphates to sulphuretted hydrogen.

The gases in water may be estimated by boiling the water, all atmospheric air being excluded, and collecting the gases driven off. Carbonic acid may then be absorbed by solution of caustic potash or soda, and oxygen by solution of pyrogallate of potash or sodic hyposulphite, while the residue will be nitrogen. The gases are stated as so many c.c. per litre of water, and correction must always be made for temperature and pressure.

For the determination of oxygen alone, a very elegant method is that of Winkler, which depends (1) on the oxidation of manganous oxide into manganic oxide by the oxygen contained in the water; and (2) on the subsequent reduction of manganic oxide by iodide of potassium, the iodine liberated representing the oxygen which has been used up in the chemical reaction. The solutions required are—(1) a solution of manganous chloride; (2) a solution of iodide of potassium; (3) a solution of caustic potash; (4) strong hydrochloric acid; (5) a solution of thiosulphate of sodium, of which 10 c.c. is equivalent to 1 c.c. oxygen; (6) starch solution as an indicator.

The equations showing the reactions are as follows:—

$$MnCl_2 + 2\ KOH = Mn(OH)_2 + 2\ KCl.$$
$$2\ Mn(OH)_2 + O + H_2O = Mn_2(OH)_6.$$
$$Mn_2(OH)_6 + 6\ HCl = Mn_2Cl_6 + 6\ H_2O.$$
$$Mn_2Cl_6 + 2\ KI = 2\ MnCl_2 + 2\ KCl + I_2.$$
$$I_2 = O.$$

The oxygen is expressed as c.c. per litre.

Thresh's method for the estimation of oxygen is somewhat similar, but is more complicated: sulphuric acid, sodic nitrite, iodide of potash, thiosulphate of sodium, and starch solution being used. The oxygen is stated as mgrms. per litre.

Deductions from Analytical Results.—The total solids found in water vary in quantity with the source of the water. A pure potable upland surface water may only contain 2 to 3 parts per 100,000, and should not contain more than 8 to 10; while deep well water may still be usable, though 30 to 40 parts per 100,000 be present.

The residue, after evaporation, should not blacken on ignition, and the solids capable of volatilisation should not exceed 1·5 parts per 100,000.

Markedly impure waters often contain more total solids than 70 parts per 100,000.

Permanent hardness should not exceed 2 grs. per gallon, and the greater it is the less likely is the water to be suitable for domestic purposes, though 4 grs. per gallon does not render a water non-usable.

The total hardness should be under 6 grs. per gallon, though twice this quantity may be admissible.

The introduction of soft water as a town supply always results in a great saving of expense, and it has been calculated that each degree of hardness involves a waste of more than 1 lb. of soap for every 1000 gallons of water used in washing.

A water with a fixed hardness of from 4 to 6 grs. per gallon, and a total hardness of from 12 to 20 grs. per gallon, is wholly unsuitable for domestic use.

If the chlorides be not more than ·5 to 1·5 parts per 100,000, the water may be regarded as pure and wholesome in this respect. Any larger quantity should induce a comparison with other waters from the same district. If the chlorides should reach 5 parts per 100,000, the usable limit is attained.

In a pure water the free ammonia may be ·002 per 100,000, and a water containing more than ·005 per 100,000 should not be used for drinking purposes.

Albuminoid ammonia is admissible up to ·005 per 100,000 in a pure water, and to ·01 in a usable water.

A large amount of albuminoid ammonia, without a corresponding excess in the free ammonia and chlorides, frequently indicates a peaty source, whereas, were the latter also freely present, the water might be from a deep well and yet wholesome enough. If, however, it were from a shallow well, a suspicion of sewage contamination would be at once engendered.

Nitrites and nitrates should be absent from a good potable water, or at the most only traces of the latter should be present. Absence of nitrites is essential, and the presence of nitrates should only be tolerated when they are indubitably derived from the solution of strata whose rock components are nitrates.

The Rivers Pollution Commissioners, however, found that even rain water may contain as much as ·032 parts per 100,000 of nitrates. Any excess of nitrogen above this amount represents nitrogen derived from oxidised animal matter with which the water has been in contact.

The organic matter, expressed in terms of oxygen required to oxidise it, should not exceed ·1 part per 100,000. The oxygen consumed by organic matter is not a very reliable guide, owing to the varying capacities of oxidation exhibited by different forms of organic matter. A water with a high oxygen-consuming power is probably bad, but one with a low oxygen-consuming power is not therefore of necessity pure, and the ammonia estimation should always be taken into account.

The relation of the organic carbon to the organic nitrogen is of importance. The more closely they approach each other in quantity, the more likely is it that there is contamination with sewage.

In the case of a fresh infusion of peat contaminating a drinking-water, the carbon and nitrogen may be present in the proportion of 18 to 1, while in the case of sewage pollution there may be 6 of carbon to 1 of nitrogen.

Water is unsuitable for drinking if it contain more than 1 gr. of iron per gallon, or 1·5 parts per 100,000. It must always be remembered that in a chalybeate water some of the total hardness is due to iron.

A good potable water should contain no trace of lead, and more than $\frac{1}{20}$ gr. per gallon, or ·07 parts per 100,000, is sufficient to condemn any water for drinking purposes.

A wholesome potable water contains from 6 to 9 c.c. of oxygen per litre. In a very impure water oxygen may be entirely absent. It must be noted, however, that sometimes deep well water contains very little oxygen, and then the carbonic acid is usually in excess. An explanation may be found in the composition of the ground air with which the water is in contact.

Most waters contain very little carbonic acid, save those from an underground source, in which as much as 130 mgrms. of free CO_2 per litre has been found. A water with both free and combined carbonic acid often gives an amphoteric reaction. It is possible, therefore, for an alkaline water to contain enough carbonic acid to enable it to dissolve lead.

Suspended and Sedimentary Matter.—There is an infinite variety of suspended and sedimentary matter which may be present in water. Briefly, it may be classed into animal, such as water beetles, and their larvæ, water fleas, skip-jacks, minute leeches, worms, their ova and embryos, rotifers, crustacea, epithelium, hairs, wool, skin, etc., and floating particles of sewage; vegetable, such as all kinds of plant débris, cotton and linen fibres, paper, algæ and diatoms, etc.; mineral, such as sand, clay, chalk, and iron. In examining for these, the water should be allowed to stand in a conical glass with a rounded bottom, and the sediment removed by a straight pipette and looked at microscopically.

Conclusions.—The very multiplicity of the matters present is a source of difficulty in determining the meaning of their presence. Some, such as sewage, point at once to dangerous contamination.

The presence of *Beggiatoa alba*, the so-called sewage fungus, may or may not indicate pollution with sewage, but is certainly suspicious, as it grows in the effluents from factories and in water rich in sulphates. Fouling by house waste, fæces, etc., is indicated by the discovery of starch granules, particles of meat and vegetables, human hair, intestinal worms or their ova, and husks of corn.

The presence of green algæ indicates that the water contains little organic matter; certain algæ, on the other hand, feed on organic matter, and cannot exist unless it be present in considerable quantities.

Micro-organisms.—The varieties found in water belong to the three classes known as moulds, yeasts, and bacteria. The two former may render a water unfit for use owing to the large quantity which may be present, making the water unsightly and even irritant to the consumer; while the last-named, even though in comparatively small quantities and not affecting the appearance of the water, may yet be of such a pathogenetic nature as to render the water extremely dangerous.

A potable water should contain no pathogenetic bacteria, and less than 100 non-pathogenetic forms per 1 c.c. after filtration, and not more than 500 c.c. previous to filtration.

The number of micro-organisms present in river water varies very largely in different rivers, at different seasons of the year, and according to the proximity of towns. Much depends on the nature of the country which the river traverses and drains, *i.e.* whether or not under cultivation, heavily manured, etc. Thus, before any great contamination, such waters as those of the Spey and Dee have been found to contain less than 100 microbes per c.c. In the Thames the mean annual average reaches 20,000, but the number is much greater during the winter, and is least during the summer months. This seasonal variation is true of other rivers, and is probably largely dependent on the surface washing of the adjacent land by the autumn and winter rains. In summer many rivers are chiefly fed by springs in their beds, the water of which is comparatively free from micro-organisms. As a rule, a river water below a town contains many more microbes than the same water before it has reached the town. The Seine above Paris contains only 300 microbes per c.c., while after traversing the city as many as 200,000 per c.c. have been found.

In lakes, as in rivers, there are more micro-organisms in winter than in summer; but, on the whole, lake water contains fewer than river water, and most are to be found near the margins. Spring water is usually free from any large number of organisms, in this way resembling the water of deep and artesian wells, which rarely contain more than 30 per c.c. Shallow well waters, on the other hand, are apt to be loaded with microbes.

Neither snow nor ice are free from micro-organisms, but there are very few in the former when freshly fallen. The number in the latter depends on the character of the water from which the ice was formed.

Sunlight, sedimentation, temperature, movement, and the organic matter present, influence the number of micro-organisms present in water.

VARIETIES.—From a hygienic point of view, the microbes found in water may be classed as—(*a*) non-pathogenetic, (*b*) pathogenetic.

(*a*) *Non-pathogenetic.*—These may be divided into—(1) those whose presence is of no special significance, and (2) those which indicate possible pollution.

1. Among these may be mentioned the following micrococci:—*M. agilis*, *M. aquatilis*, *M. luteus*, *Sarcina;* and numerous bacillary forms, such as *B. arborescens*, *B. aquatilis sulcatus* (which closely resembles *B. typhosus* morphologically), *B. aurantiacus*, *B. fluorescens liquefaciens*, and *non-liquefaciens;* three varieties of potato bacillus, *i.e. B. mesentericus vulgatus*, *fuscus*, and *ruber; B. mycoides* (resembling *B. anthracis*), *B. prodigiosus*, *B. ramosus*, *B. subtilis*, and *B. ubiquitus*. Many spirilla are also found in water; the most important is the *Vibrio aquatilis* of Günther, which is differentiated from the *V. choleræ* by the absence of indol production.

2. Of these, the most important are *B. coli communis* in either its typical or atypical forms. A large number of the coliform bacilli strongly suggest sewage contamination, though the mere presence of the *B. coli* does not necessarily condemn a water. It should, however, instigate a searching bacteriological examination for pathogenetic forms. The *B. proteus* in its two most common varieties, *vulgaris* and *zenkeri*, is rarely found in absolutely pure water. If it exists along with *B. coli*, it points to sewage pollution. The *B. enteritidis sporogenes*, when found in water, renders it practically certain that sewage contamination has taken place. It has been discovered that this organism may be present even when sewage is diluted in water to the extent of 1 part in 500,000. Of less importance are *B. liquefaciens*, *B. lactis aerogenes* and *cyanogenus*, *B. megatherium*, *B. ochraceus* and *B. ureæ*.

(*b*) *Pathogenetic.*—The organisms of cholera and enteric fever are by far the most important and those generally requiring to be sought for; but it is probable that other organisms may occasionally be present in drinking-water, such as the bacillus of anthrax, the malarial plasmodium, and the *amœba dysenteriæ*, while there is no reason to suppose that the specific causes of other communicable diseases may not sometimes find a habitat in water.

Water derives its micro-organisms chiefly from soil and air, the former being the more important source. Waters fouled by organic matter contain more organisms than those not so polluted, and in such waters saprophytic varieties frequently flourish at the expense of the pathogenetic. The *B. typhosus* has a greater vitality in sterilised than in impure water. Experiments differ greatly as to the length of time it survives, but there seems no doubt that it can live much longer in deep well water than in that of such a river as the Thames. It would appear that the vibrio of cholera does not exist so long in unsterilised water as does the enteric bacillus; but so many factors influence the vitality of these microbes in water, that it has been found very difficult to come to any definite understanding regarding their conditions of life in water.

Collection of Sample for Bacteriological Analysis.—This is best done in narrow-necked, glass-stoppered, sterilised bottles, the outsides of which should be carefully washed before they are dipped beneath the surface, with the stoppers in situ. After the bottle has been dipped, the stopper is removed, the water collected, a little of it then poured out, and the stopper, which has been kept from any possible contamination, replaced, but not sealed down in any way. In the case of water taken from a tap, the stream should be allowed to flow for a time, then turned off, the nozzle of the tap sterilised by heat, and after the water has again been turned on for a few minutes, the required sample may be taken. The temperature of the water must be determined, and, if from a tap, the thermometer should not be inserted in the stream, owing to the error introduced by friction.

If the examination can be conducted on the spot, this collection should be altogether dispensed with, and the water directly added to the necessary culture media. If the bottle specimens have to be conveyed any distance, they should be surrounded by ice to hinder the multiplication of organisms, which would inevitably ensue were the water kept at the ordinary temperature. This procedure, however, may be inimical to pathogenetic microbes present in the water.

Examination.—This should be conducted as soon as possible, the temperature of the water at the time of examination being noted. A measured quantity is added by a sterilised pipette to tubes containing liquefied gelatine-peptone or agar, from which plates are prepared and incubated, the former at 18° to 20° C., the latter at 37° C. At the end of eight days the resulting colonies are counted, unless liquefaction in the case of the gelatine plates has rendered an earlier enumeration essential.

Although all the bacteria in the water will not develop at these temperatures, a very fair idea is obtained of the number and variety present. Subcultures from the colonies must then be made. If 1 per cent. of albumin peptone and ·5 per cent. of salt be added to the water itself, a medium is formed in which any organisms present can be cultivated. In addition, special examinations may be conducted with special media and at special temperatures, in order to isolate organisms which do not develop in the routine examination. Thus for nitrifying organisms Winogradsky's medium or nitrite agar is useful, while the thermophilic bacteria will only grow at high temperatures.

Further, provision may be made for anaerobic culture, as anaerobes occur in water, *e.g. B. enteritidis sporogenes*. In examining water for the *enteric bacillus*, several litres of the water should be filtered through a sterile Pasteur-Chamberland filter, the candle washed with sterile distilled water, and the various media inoculated from the washings. Tubes of broth, jelly, and agar are to be inoculated, and plates prepared from the last two. Phenolated broth and jelly tubes should also be inoculated. Broth and agar are to be incubated at 37° C., and jelly at 24° C. Rémy's jelly and Elsner's potato-gelatine medium form favourable pabula for the bacillus. Broth tubes, with Parietti's fluid added, are also useful for isolating the organism. For the preparation of these media and the details of the methods employed, the student is referred to his laboratory work.

The *B. coli communis* grows on these special media, and for the differential culture reactions between it and the *B. typhosi*, see p. 15. The neutral red reaction is given by *B. coli* within one to two days, but never by the *B. typhosus*, and may prove a useful distinguishing test in water analysis.

For the *vibrio of cholera* the preliminaries are the same as for the typhoid bacillus. From the washings, tubes or flasks of broth, or Durham's peptone solution, are inoculated, incubated at 37° C., and tested for indol at the end of twenty-four hours. It is well to inoculate one tube or flask at first, and, when growth has occurred, to successively inoculate a series, the second from the first, the third from the second, and so on. When a fairly pure culture has been obtained, it may be plated out in the usual way. If the vibrio develop, it must be isolated and stained as mentioned on p. 33.

For the *B. enteritidis sporogenes.* After the preliminaries detailed above, the washings should be heated at 80° C. for a quarter of an hour, and then a tube of milk should be inoculated and incubated anaerobically at 37° C.

For the *B. tetani* the procedure is the same as for *B. enteritidis*, except that instead of milk, broth containing glucose and sodium formate is inoculated.

For the *B. anthracis* the preliminaries are the same as for the former; agar is used as the medium, and the organism is cultivated aerobically at 37° C.

Conclusions from bacteriological examination for pathogenetic microbes.—Should any pathogenetic organism be present, the water supply should be replaced by one not similarly polluted, or, failing this, it must be boiled or otherwise sterilised. A water which is suspiciously connected with an outbreak of epidemic disease should not be used even if the specific organism cannot be demonstrated. It is at all times a matter of extreme difficulty to obtain cultivations of pathogenetic organisms, and especially of the typhoid bacillus, from an infected drinking-water. In the great majority of undoubted water-borne epidemics of typhoid fever, careful examination has failed to isolate the specific bacillus. Indeed, so much is this the case, that the fact has lent weight to the argument of those who believe that under certain conditions the *B. coli communis*, an organism much more frequently present and easy of demonstration, can become transformed into its pathogenetic congener. The balance of evidence, however, refutes such a conclusion. Unless the pollution of drinking-water with the typhoid bacillus continue for a considerable time, it is extremely difficult to find the bacillus in the water which has given rise to an epidemic, because the incubation period of enteric fever is often as long or longer than the length of time the typhoid bacillus can live in an unsterilised water.

It would appear that the cholera vibrio is more readily found in drinking-water during cholera outbreaks than is the typhoid bacillus during epidemics of enteric fever; but it must be remembered that other spirilla morphologically resembling the vibrio, and having similar pathogenetic action on animals, have been isolated from water samples.

It is to be noted that a water which on examination may contain comparatively few organisms, and these of a non-pathogenetic type, may yet not be suitable for drinking purposes, as amongst these bacteria there may be some which will cause it, on standing, to undergo putrefaction and render it unsuited for potable purposes.

SUMMARY OF CHARACTERS OF A GOOD AND A BAD WATER.

Characters.	Good.	Bad.
PHYSICAL—		
Clarity	Clear.	Turbid.
Colour	Nil.	Brown or yellow.
Smell	,,	Present.
Taste	Palatable.	Unpleasant.
Suspended matter	Nil.	Marked.
Sediment	,,	Present, whether of animal or vegetable origin.
CHEMICAL (in parts per 100,000)—		
Reaction	Neutral.	Marked acid or alkaline, especially the latter.
Dissolved solids	Under 10.	Above 50.
Hardness { Permanent	2°.	4°–6°.
Hardness { Total	6°.	12°–20°.
Chlorides	1·5.	5–10.
Free ammonia	·002.	·01.
Albuminoid ammonia	·005.	·015.
Nitrites	Nil.	Present.
Nitrates	Nil, or less than ·05.	,,
Organic carbon	·1.	·3.
Organic nitrogen	·02.	·03.
Organic matter in terms of oxygen	Under ·1.	·2.
Sulphides	Nil.	Present.
Metals	Nil, or mere trace of iron.	Much iron or any trace of poisonous metal.
Gases { Oxygen	6–9 c.c. per litre.	Slight or nil.
Gases { Carbonic acid	Slight.	Marked.
BACTERIOLOGICAL—		
Micro-organisms :		
Non-pathogenetic { Filtered	Less than 100 per c.c.	Over 100 per c.c.
Non-pathogenetic { Unfiltered	500 per c.c.	Over 500 per c.c.
	Few *coli*, *proteus*, and no *B. enteritidis sporogenes*.	Many *coli*, *proteus*, or any *B. enteritidis sporogenes*.
Pathogenetic	Nil.	Present.

FOOD.

DEFINITION.—(*a*) *Legal.*—By the Sale of Food and Drugs Act, 1875, food was defined as "every article used as food or drink by man other than drugs or water." By the Act of 1899, food "includes every article used for food or drink by man other than drugs or water, and any article which ordinarily enters into or is used in the composition or preparation of human food, and also flavouring matters and condiments."

(*b*) *Medical.*—Food is any edible or potable substance capable of absorption by the alimentary canal and destined to further growth or nutrition, or to supply a fuel for the production of energy and heat.

CONSTITUENTS.—Primarily, food constituents may be divided into those containing nitrogen and those without it.

THE NITROGENOUS ALIMENTS are proteids which may be classed as albuminates, albuminoids, and extractives.

Albuminates.—*Origin.*—These may be derived from either the animal or the vegetable kingdom, and are present in most animal and vegetable foods.

Varieties.—In this group are included, albumin, casein, globulin, fibrin, myosin, syntonin, glutin, and legumin.

Chemical composition.—Albuminates are made up of nitrogen, carbon, oxygen, hydrogen, sulphur, in the percentage proportion of 16 parts by weight of nitrogen, 54 of carbon, 22 of oxygen, 7 of hydrogen, and 1 of sulphur. The proportion of nitrogen to carbon is as 2 to 7.

Characteristics.—They are essential for the maintenance of life, and no other form of food can be substituted for them. They are colloid bodies, and do not readily pass through the alimentary mucous membrane. Some are soluble in water, but many are insoluble. They are coagulated by heat, acids, and alcohol. Saturated solutions of neutral ammonium sulphate or sodio-magnesic sulphate precipitate albuminates, which further are lævo-rotatory.

Products of metabolism.—In the process of digestion, albuminates lose their colloid character and are converted into albumoses and peptones, which are absorbed and pass into the blood as albumin, glycerine, and fats.

These are then conveyed to their destination, where they fulfil their various functions, become changed, and are in part excreted as urea, uric acid, hippuric acid, creatinin, xanthin, leucin, and tyrosin, all of which contain carbon, nitrogen, hydrogen, and oxygen. The final products are carbonic acid, water, and urea. Some of the albuminate material is also transformed into ptomaines and leucomaines, which under normal conditions are split up into excretory products.

Peptones differ from albuminates in having the capacity of readily passing through animal membranes, in not being coagulated by heat or precipitated by ammonium sulphate. One test for peptones is the biuret reaction, which consists in the production of a violet-red colour when a weak solution of copper sulphate is added to them in the presence of an alkali.

Destination and function.—In their altered form the albuminates serve to nourish the various nitrogenous tissues and fluids of the body, to provide the materials required for growth and repair, and to furnish oxidisable matter whence energy and heat can be obtained. Further, they may also to some extent be a source of fat. In addition, they stimulate the gastric secretion suitable for their digestion.

Albuminoids.—*Origin.*—They occur abundantly both in the animal and vegetable kingdoms.

Varieties.—Chondrin, elastin, fibroin, gelatin, keratin, mucin, nuclein, ossein, and spongin.

Chemical composition.—These are proteids which contain nitrogen, carbon, hydrogen, oxygen, and sometimes sulphur, the proportion of nitrogen to carbon being as 2 to 5·5, there being about 2 per cent. more nitrogen in the albuminoids than in the albuminates.

Characteristics.—Generally speaking, these are the same as the albuminates, but they dissolve easily in hot water.

Products of metabolism closely resemble those of the albuminates.

Destination and function.—To provide oxidisable matter and aid the production of energy and heat. They probably play a very insignificant part in the processes of growth and repair, but serve as very effectual sparers of albuminates.

Extractives.—*Origin.*—They are found in various animal tissues, occurring in small quantities, and derived from the metabolism of other forms of proteid in those tissues. Some are also found in the vegetable kingdom.

Varieties.—Kreatin, kreatinin, karnin, xanthin, asparagin, etc.

Chemical composition.—They all contain carbon, hydrogen, nitrogen, and oxygen, but in many cases the exact constitution has not been fully determined.

Characteristics.—They are found largely in the juice of meat, are soluble in hot water, and are more abundant in mature than in immature animals, while their flavour depends much on the manner in which the animal has been fed.

Products of metabolism.—Urea, carbonic acid, and water.

Destination and function.—They probably act as aids to, and controllers of, the digestive process, especially when the albuminoids are present. They powerfully stimulate the flow of the gastric juice.

The vegetable extractives, such as asparagin, may play a part in preventing intestinal decomposition and consequent loss of proteid material.

The Non-Nitrogenous Aliments are the fats, carbohydrates, organic acids, mineral salts, phosphorus, and water.

Fats or Hydrocarbons.—*Origin.*—They are derived both from animal and vegetable tissues.

Varieties.—Butyrine, margarine, olein, palmitin, and stearin.

Chemical composition.—Fats are compounds of glycerine with the fatty acids, such as butyric, margaric, oleic, palmitic, and stearic acids. They contain carbon, hydrogen, and oxygen, in proportions which vary in different fats. The relative amounts of oxygen and hydrogen present are not those which obtain in water, there being too little oxygen to unite with all the hydrogen. Some fats in food are neutral, others contain excess of fatty acid. The various fats have different melting points.

Characteristics.—The lower the melting point of the fat, the greater its absorption; thus it is probable that vegetable fats, being of a more oily nature than those of animal origin, are more readily assimilated.

Products of metabolism.—When fats undergo change they are split up into glycerine and fatty acids, and the fatty acids unite with alkalies to form soaps. The final products of fats are carbonic acid and water.

Destination and function.—Fats are unacted upon by the saliva and gastric juice, but they markedly stimulate the secretion of the tryptic ferment and the bile. They are emulsified by the pancreatic juice and the bile, are absorbed by the small intestine, and pass into the blood and lacteal vessels. Their function is to build up the fat of the body, and to form fuel whose oxidation provides energy and heat. By virtue of this latter action they spare the proteids, which can thus be more fully utilised for purposes of tissue repair.

Carbohydrates.—*Origin.*—They occur in plants and animals, but to a much greater extent in the vegetable than in the animal kingdom.

Varieties.—Cane sugar, cellulose, dextrin, galactose, glycogen, grape sugar, lactose, lævulose, maltose, pectose, and starch.

Chemical composition.—They are composed of carbon, hydrogen, and oxygen, the carbon never being less than 6 atoms, and the hydrogen and oxygen being in the same relative proportion as that in which they occur in water. They are solid, neutral in reaction, may have a sweet taste, and are either dextro- or lævo-rotatory. Carbohydrates are classified as mono-, di-, or poly-saccharids, according as the molecule is composed of a simple saccharid, such as glucose ($C_6H_{12}O_6$); a combination of two simple saccharids with loss of water, such as maltose ($C_{12}H_{22}O_{11}$); or a combination of more than two simple saccharids with loss of water, such as starch ($nC_6H_{10}O_5$).

Characteristics.—Most of the carbohydrates are characterised by the facility with which they are absorbed.

Products of metabolism.—Those which are not already sugars, with the exception of cellulose, which is excreted unchanged, are converted into sugars and are absorbed. The sugars are then in part oxidised into carbonic acid and water, and in part converted into glycogen, which in its turn becomes carbonic acid and water, and in part form fats, and in part provide organic acids which unite with various alkalies to form salts.

Destination and function.—The carbohydrates begin to be utilised in the mouth, where they are acted upon by the ptyalin of the saliva and partly changed into grape sugar, or, as in the case of starch, into dextrin. No additional action takes place till the intestine is reached, where the pancreatic ferment and the intestinal juice, the secretion of both of which has been slightly stimulated by the presence of the carbohydrates in the mouth, convert the remainder of the starch into glucose, which is absorbed, conveyed to the liver, and stored up in the cells of that organ as glycogen. The latter is used up by the muscles as required, and supplies heat and energy. The carbohydrates thus save the excessive waste of proteids and fats, and retard intestinal putrefaction. They also supply salt-forming acids which unite with alkalies to form carbonates, and determine in some measure the alkalinity of the blood. To a small extent fat itself may be directly formed from carbohydrate foods.

Organic Acids.—*Origin.*—They are derived chiefly from fresh fruits and vegetables, and to a lesser extent from fresh meat and milk.

Varieties.—Acetic, citric, lactic, malic, oxalic, and tartaric.

Chemical composition.—They are compounds of carbon, hydrogen, and oxygen, in which the amount of oxygen present is sufficient, or more than sufficient, to combine with the hydrogen to form water. Thus the formula of acetic acid is $C_2H_4O_2$, of oxalic acid $C_2H_2O_4$.

These acids may either exist free in the food or in combination with alkalies, *e.g.* potassium, as salts.

Characteristics.—They possess a sharp refreshing flavour, and are pleasant to most palates.

Products of metabolism.—Metabolism of these acids results in the formation of carbonates.

Destination and function.—These carbonates serve to maintain the alkalinity of the blood and other fluids of the body, and to diminish the acidity of the urine. The acids may yield a small stock of heat and energy, the result of their oxidation.

Mineral Salts.—*Origin.*—They are found both in animal and vegetable foods, sodium salts being more common in the former, and those of potassium in the latter. In some instances, salts, *e.g.* sodium chloride, are taken as food in their natural condition.

Varieties.—Chloride of sodium, phosphates of lime, potash, soda and magnesia, sulphates, and iron salts.

Destination and function.—The chlorides form the source of the hydrochloric acid requisite for the gastric juice, they assist in the digestion of proteids, and as a condiment they stimulate appetite and the alimentary secretions. It is doubtful if the phosphates of lime, potash, and magnesia are bone-builders, as has been so long supposed, since they seem to be excreted almost unchanged. Potash salts nourish the cells generally, especially the red blood cells and the muscles, while those of soda are required by the intercellular fluids. The function of the sulphates is unknown ; that of iron is to supply hæmoglobin to the red blood corpuscles.

Phosphorus.—*Origin.*—It is contained in food, both animal and vegetable, more especially in the former.

Varieties.—Glycero-phosphoric acid, lecithin, nuclein, phospho-carnic acid, and phosphates.

Chemical composition.—As the varieties show, phosphorus may occur in complex organic compounds or as mineral salts.

Destination and function.—The organic compounds of phosphorus are true bone-builders, being of special importance in the young.

Water.—*Origin.*—Apart from its imbibition as a fluid, water is contained in all foods, more especially in vegetables.

Varieties.—Natural, aerated, mineral.

Destination and function.—Water is not absorbed by the mucous membrane of the stomach at all, and does not pass into the system until it reaches the intestine, although it slightly stimulates the gastric secretion, and, if hot, powerfully induces gastric peristalsis. Its most important function is to act as a flush for waste products, while it also softens certain articles of diet, thereby rendering them more easy of digestion. Water forms no less than two-thirds of the body weight, and is stored up in the tissues. Between these and the blood an interchange is constantly taking place, the activity of which depends on the amount of water consumed. When little water is drunk, the blood maintains its fluidity by absorption of water from the tissues. Aerated waters, by virtue of the carbonic acid gas they contain, aid digestion both mechanically and chemically. Mineral waters contain salts and sometimes iron, which affect metabolism as already described. In most cases the solvent rather than the dissolved solids is the active agent, the water acting as a flush to the alimentary and urinary tracts.

THE FOOD-STUFFS.

A. COMPOSITION.

1. *Of Animal Origin.*—(*a*) *Meat* contains proteids, fats, acids, salts, and water. The proteids are albumin, myosin, hæmoglobin, etc., and form about 20 per cent. of the meat, while water forms from 70 to 75 per cent., but there is much less water where fat is present in any quantity. The amount of fat varies greatly from what is found in lean beef to what occurs in fat bacon. The acids develop after death, and partially digest the muscle fibre. They consist of sarcolactic acid and acid phosphates, which by their action render newly killed, and therefore tough, meat tender in the course of a few hours.

Phosphoric acid and potash constitute the chief salts of meat, hence meat is necessary for the building up of muscular tissue. Besides the flesh, bone may be sold with the meat. It consists of gelatine, fats, salts, and water, and its nutritive value is high. The percentage amount of the proximate principles present in various kinds of meat is given in the following table :—

Meat.	Proteid.	Fat.	Salts.	Water.
Beef (lean)	20·71	1·74	1·18	76·37
Beef (medium fat) . . .	20·96	5·41	1·6	72·03
Mutton ,, . . .	14·5	19·5	0·8	65·2
Lamb ,, . . .	18·5	16·5	1·1	63·9
Veal (fat)	19·2	7·2	1·33	72·27
Pork (medium fat) . . .	12·3	26·2	0·6	60·9
Bacon	8·1	65·2	4·4	22·3
Horse-flesh	21·7	2·5	1·1	74·7
Rabbit	21·4	8·7	1·1	66·8
Fowl	23·3	3·1	1·0	72·6

(*b*) *Fish*, like meat, contains water, proteid, and fat, but there is more water and gelatine than in meat, and less albuminate and extractives. As Hutchison has pointed out, the popular idea that fish contains much phosphorus is based on a fallacy.

(*c*) *Eggs* consist of proteid and mineral matter, fat, and water. The fat is in the form of palmitin, stearin, and olein, and is present only in the yolk, which contains, besides water, the proteids vitellin and nuclein; phosphorus compounds, *e.g.* cholesterin lecithin, and glycero-phosphoric acid; the glucoside cerebrin; and colouring and mineral matters, especially phosphoric acid, much lime, and iron.

The white of egg contains only proteid (egg albumin), salts, and water.

(*d*) *Milk.*—In cow's milk are found proteids, carbohydrates, fats, salts, and water. The proteids of milk are casein and a serum albumin (lactalbumin), the former having its solubility increased by the phosphate of lime present, which keeps it in opalescent solution, and so causes in large measure the characteristic appearance of milk. The casein does not coagulate when the milk is boiled, as is the case with the small quantity of lactalbumin present. The carbohydrate is lactose or milk sugar, which constitutes 5 per cent., and is a hard, gritty sugar, with a slightly sweetish taste. It is dextrorotatory. Lactose undergoes decomposition by the *B. lactis* with the formation of lactic acid, the familiar process known as souring of milk. This may occur either before or after the ingestion of the milk. Fat constitutes 3 to 4 per cent. of the milk, in which it is present as a fine emulsion. On standing, most of the fat rises to the surface in the form of cream, and if this be skimmed off, the proportion of fat present in the skim milk is reduced to about 1 per cent. If, however, the cream be removed by means of a centrifugal separator, practically no fat is left in the milk. A "separated" and a "skimmed" milk thus differ in the quantity of fat they contain, but in the former case the milk is in a fresh condition, while the latter, being a lengthy process, the milk is more likely to be sour. Cream has much the same composition as milk, only it contains less water and more fat. The principal salts of milk are phosphates of lime, potash and soda, and citrate of lime, the total proportion of these ingredients being ·7 per cent. Water forms 87 to 88 per cent. of cow's milk, and acts as a menstruum for the other constituents. Human milk contains more sugar, more fat, and less casein than cow's milk. The milk of the ass most nearly approaches human milk in composition.

(*e*) *Butter* is made when cream is churned, the oil globules coalescing, and in doing so taking up some of the casein. Butter also contains lactose and water. Butter fat forms about 83 per cent. of the butter, and consists of glycerides of soluble and insoluble acids, the latter constituting not more than 88 per cent. of the butter fat. The chief soluble acid is butyric acid, and there are also capric, caproic, and caprylic acids. These form some 5 to 6 per cent. of the butter fat, while the insoluble fatty acids are palmitic, stearic, and oleic. Of these, oleic acid is the most abundant. Salt is added to most butters as a preservative, and there may be as much as 8 per cent. present in salt butter. The casein and lactose together form 2 per cent. of the butter, and the water should not exceed 12 per cent.

Butter owes its flavour to the growth of micro-organisms in the cream, and may be turned rancid by the bacterial decomposition of the casein.

(*f*) *Margarine* is a substitute for butter made from beef and mutton fat, by removing most of the stearin and leaving the palmitin and olein. It contains about the same proportion of fat as butter, but differs from it in being almost devoid of the glycerides of the soluble acids. It contains less water and more ash than butter, and possesses very little casein.

(*g*) *Cheese* consists of a proteid (casein), fat and water, the salts of lime, and sometimes milk sugar. It is prepared from milk by precipitation of the casein by rennet or an acid, such as vinegar. The curd is pressed and then allowed to ripen under the influence of bacterial action. The three principal constituents are present in about equal proportions.

2. *Of Vegetable Origin.*—(*a*) *Wheat.*—The wheat grain somewhat resembles an egg, as it consists of an outer envelope, the bran, enclosing the germ and the nutriment for the germ, namely, the endosperm. In whole-meal flour all these elements are included, and in this way all the chemical constituents of the grain are well represented in the flour, as the bran is rich in mineral matter and cellulose, the germ in proteid and fat, and the endosperm in starch. Each of the parts, however, contains proteid, carbohydrate in the shape of starch, sugar, or dextrin, fat, cellulose, mineral matter, and water. A white-meal flour is prepared from the endosperm, and is consequently rich in starch. The proteid of wheat is mainly a vegetable albumin termed glutin, which exists in varying quantities in different wheats, and forms a sticky, coherent mass when mixed with water. The carbohydrate is mainly starch ; there is but little fat or mineral matter, and the water varies in amount. Flour is the ground wheat grain either in whole or in part. A whole-meal flour contains approximately of proteid 14 per cent., carbohydrate and cellulose 71 per cent., fat 2 per cent., mineral matter 1 per cent., and water 12 per cent. Contrast with this a flour made from the endosperm, whose percentage composition is—proteid 10, carbohydrate and cellulose 76, fat 1, mineral matter ·5, and water 12·5.

Wheaten bread is a mixture of wheat flour, water, yeast, and salt, in the form of a dough, which has risen before a hot fire and been thereafter baked in an oven. The coherency of bread is due to its glutin, its sponginess to its permeation with carbonic acid, the result of the yeast fermentation.

In making aerated bread the yeast is dispensed with, and carbonic acid is forced into the dough under pressure. Baking powders consist of an acid and an alkali (which act one on the other, evolving carbonic acid), and are used as substitutes for yeast. Bread, like flour, is rich in proteid and starch, but poor in fat and salts. Thus a whole-meal bread may contain 11 per cent. of proteid, 44 per cent. of carbohydrate and cellulose, ·5 per cent. of fat, 1·5 per cent. of salts, and 43 per cent. of water. A white-meal bread may have a percentage composition of proteid 8, carbohydrate 50, fat 1, salt 1, and water 40. The crust and the crumb differ in composition, the former consisting largely of proteid, soluble starch, and dextrin, while it has a much smaller proportion of water than the crumb.

(*b*) *Oats.*—The oat grain consists of a husk enclosing a seed, which is still further protected by two or three envelopes. The husk being removed, the seed and envelopes are ground to form oatmeal, which is the most nutritious of all the cereal preparations. This is due to the large quantity of proteid, fat, and mineral matters present. The general percentage composition of oatmeal is proteid (albumin) 15, carbohydrates and cellulose 67, fat 8, mineral matter 2, water 8.

Oat flour is oatmeal from which the branny particles derived from the envelopes have been separated. Grinding of the oat grain has recently been superseded by rolling, combined with the application of heat, and the well-known "Quaker" oats are prepared in this manner. Oats contain no glutin, and consequently cannot be made into bread.

(*c*) *Barley.*—The grain of barley resembles that of wheat, but its envelopes are not so tough. Barley meal is the whole grain ground. Scotch barley is the ground grain devoid of husk. Pearl barley is the grain alone, without husk, and polished. Patent barley is pearl barley ground to flour. The two latter forms are those commonly used as food. Its composition is much the same as that of wheat, but there is less proteid and more fat and mineral matter, the ash being rich in iron and phosphates. There is no glutin in barley, and consequently bread cannot be manufactured from it unless it is mixed with wheat flour. By the germination of the barley grain malt is produced, owing to the action of the ferment diastase upon the carbohydrate.

(*d*) *Rye.*—The rye grain is spiked, but otherwise is very like that of wheat, and contains glutin. Hence rye bread can be made, and on the Continent rye is much used as a substitute for wheat. It is poor in proteid and fat, but rich in sugar.

(*e*) *Maize, Indian corn, or mealies.*—The grain of maize possesses two envelopes, and is poorer in cellulose than wheat, but much richer in fat, and consequently maize is very nutritious. It is deficient in glutin, and cannot be made into bread, but maize meal is prepared from the grain without husk or germ.

Hominy, corn-flour, maizena and oswego are all preparations of maize, the last three being largely composed of starchy elements, while hominy is maize undeprived of its proteid.

(*f*) *Rice.*—Paddy, the rice grain with the husk, is not used as food, the grain alone being employed. This is very rich in carbohydrate, especially starch, but poor in proteid, fat, and salts.

(*g*) *Millet and buckwheat* are forms of food rarely eaten in this country. The former is used as bread, the latter as cakes or porridge. Millet is fairly rich in proteid and fat, and its ash contains silica and phosphates. Buckwheat closely resembles millet, but its cellulose is in excess.

(*h*) *Peas and beans.*—These are the seeds of leguminous plants, and are peculiar in containing the proteid known as legumin, and possibly also globulin. Sulphur is common to both peas and beans, but there is more of it in the latter. Phosphorus is also present, combined with potash and lime, but peas and beans are deficient in fat and sodium chloride.

TABLE SHOWING RELATIVE ABUNDANCE OF CONSTITUENTS IN VARIOUS FOODS ACCORDING TO PERCENTAGE COMPOSITION.

Proteid.	Carbohydrate.	Fat.	Salts.	Water.
Cheddar cheese.	Arrowroot.	Butter.	Fat fish.	Fruits.
Fowl.	Sago.	Bacon.	Bacon.	Turnip.
Hare.	Tapioca.	Goose.	Cheddar cheese.	Cabbage.
Pigeon.	Rice.	Cheddar cheese.	Beans.	Carrot.
Lentils.	Rye.	Pork.	Lentils.	Milk.
Peas.	Wheat.	Lamb.	Peas.	Beef.
Wild duck.	Barley.	Veal.	Barley.	Venison.
Rabbit.	Maize.	Eggs.	Millet.	Mutton.
Beef.	Millet.	Rabbit.	Buckwheat.	Pigeon.
Beans.	Buckwheat.	Oats.	Oats.	Hare.
Venison.	Oats.	Mutton.	Rye.	Veal.
Lamb.	Lentils.	Fat fish.	Wheat.	Eggs.
Mutton.	Peas.	Milk.	Maize.	Fowl.
Veal.	Beans.	Maize.	Beef.	Wild duck.
Fat fish.	Potatoes.	Millet.	Mutton.	Rabbit.
Goose.	Yams.	Fowl.	Hare.	Fat fish.
Eggs.	Fat fish.	Wild duck.	Rabbit.	Lamb.
Oats.	Carrots.	Beans.	Venison.	Pork.
Pork.	Fruits.	Lentils.	Lamb.	Goose.
Wheat.	Milk.	Buckwheat.	Veal.	Cheddar cheese.
Millet.	Cabbage.	Rye.	Fowl.	Bacon.
Buckwheat.	Turnip.	Venison.	Wild duck.	Buckwheat.
Rye.	Cauliflower.	Wheat.	Pigeon.	Maize.
Barley.	Spinach.	Barley.	Butter.	Rice.
Maize.	Seakale.	Beef.	Eggs.	Barley.
Bacon.	Sprouts.	Peas.	Milk.	Millet.
Rice.	Celery.	Hare.	Rice.	Wheat.
Milk.		Pigeon.	Pork.	Peas.
Butter.		Rice.	Goose.	Beans.
Fruits.		Fruits.	Fruits.	Lentils.
				Rye.
				Butter.
				Oats.

(*i*) *Lentils* are rich in proteids, have as much as 60 per cent. of carbohydrates, and their ash contains iron in considerable quantities.

(*j*) *Potatoes* are tubers which contain much starch and little proteid or fat. Free citric acid renders their juice acid, and alkaline citrates are also present, so that potatoes are valuable antiscorbutics. Salts of potash form a very important ingredient, and asparagin, which is also a constituent, though not itself nutritious, is an aid to the assimilation of other principles. There is about 76 per cent. of water in potatoes.

(*k*) *Turnips and carrots* are alike in consisting chiefly of water, proteids being almost absent. The carbohydrate of turnips is pectose, while carrots contain much sugar.

(*l*) *Cabbage* may be mentioned as an example of a green vegetable. It is not nutritious save for its mineral salts, and, indeed, is mainly composed of water and cellulose.

(*m*) *Arrowroot, tapioca, and sago.*—These are simply starches, the two former being derived from roots, sago from the pith of a plant. As food-stuffs they come into the market in specially prepared forms. Farina is made from the starch of maize or potatoes.

(*n*) *Fruits.*—When fresh, fruit consists very largely of water, and is only nutritious in so far as it contains a small quantity of carbohydrate, namely, lævulose or fruit sugar, and pectin. Cane-sugar may also be present. Potash, combined with vegetable acids, forms the mineral matter in fruit, which, when fresh, is a valuable antiscorbutic. When fruit ripens, the sugar increases and the vegetable acids diminish.

(*o*) *Nuts* are remarkable for their large amount of fat, while they also possess much proteid. Their cellulose, however, is excessive, hence their indigestibility.

B. HEAT VALUE.

A comparative standard by which the various constituents of food can be judged is found in the quantity of heat produced by their complete oxidation. The unit of this standard is the *Calorie*, *i.e.* the amount of heat required to raise 1 litre of water 1° C. [Note that this unit is always spelt with a capital, to distinguish it from the calorie which is the ordinary unit of heat.]

It has been ascertained that 1 grm. of proteid or carbohydrate has a heat value of 4·1 Calories, and 1 grm. of fat a heat value of 9·3 Calories. Thus, if a particular food contain 10 per cent. of proteid, 30 per cent. of carbohydrate, and 5 per cent. of fat, the heat value of 100 grms. will be $10 \times 4{\cdot}1 + 30 \times 4{\cdot}1 + 5 \times 9{\cdot}3 = 210{\cdot}5$ Calories.

It is well to remember that when dealing with ounces and pounds of a food-stuff they must be converted into grms. before multiplying by these figures. To convert ounces to grms., multiply by 28·349. Heat and energy are closely related. Thus, if we know the heat value of a food-stuff, we can ascertain by Joule's law the energy to which it is equivalent.

C. ADVANTAGES AND DISADVANTAGES OF INDIVIDUAL FOOD-STUFFS.

The high value of meat as a food for man depends upon the large amount of proteid it contains in an easily digestible form, and it is worthy of note that the meat-eating nations of the world are the most virile. Meat, however, while capable of sustaining life for lengthy periods, is not an ideal food, owing to its lack of carbohydrate principles.

An exclusively meat diet supplies an excess of nitrogen, and does not yield sufficient carbon. Different meats vary much in the quantity and quality of fat they contain, and consequently in their heat values. Fat, moreover, may mechanically protect the meat fibre from the action of the digestive juices, hence some fat meats, such as pork, are indigestible. In other meats the consistence of the fat itself has to be considered. Thus the fat of bacon is granular and easily absorbed, that of mutton is often heavy. Again, some fats are prone to decomposition, such as those of chicken and game.

Mature meat possesses more flavour than that which is immature, owing largely to the greater presence of extractives in the former. The salts of meat increase its value and aid the action of its proteid.

Water is relatively more plentiful in the flesh of young animals than in that of old.

Apart from its constitution, the consistence of the meat itself calls for notice. Beef has a thicker fibre and possesses more intramuscular connective tissue than mutton. Veal also has a large amount of connective tissue. Freshly-killed meat is tougher than that which has hung for a time, while the muscles of different parts vary in their nature, the breast of a chicken being infinitely more tender than the flesh of the legs.

The value of meat may be affected by the manner in which the animal has been killed ; the flesh of an animal which has been bled containing less hæmoglobin, and therefore less iron. Meat has this advantage, that little of it is wasted in the system, over 90 per cent. of the solids being absorbed.

The fatter a fish, the finer a food does it make. Fish has the advantage of being very fully absorbed, but some forms, such as cod, are not easily digested. Salt fish is more indigestible than fresh fish. The proteid of fish is somewhat less nutritious than that of meat, partly owing to its smaller quantity, and partly to the absence of extractives. As far as food is concerned, the herring is probably the finest fish that swims.

Eggs, like meat, lack carbohydrate, and the phrase "as full of meat as an egg" is not a bad one whatever the egg may be, as their nutrient qualities depend on the proteid and fat which they contain. Eggs are very completely and, when cooked in certain ways, easily absorbed.

In so far as it contains all the requisite constituents for human diet, milk is a complete food, but there is too much proteid and too little carbohydrate if it is to be alone relied upon. It leaves little residue in the intestine, though this does not by any means indicate that it is very fully absorbed. It is a valuable adjunct to foods which contain less proteid, but has the disadvantage of leading to constipation. Milk is to be regarded as a food and not as a drink.

Butter is a food of great value as a fuel, but can be efficiently, if not agreeably, replaced by dripping, while margarine forms a useful and economic substitute.

Cheese is a mass of concentrated potential energy, and, owing to its large amount of proteid and fat, forms the best available substitute for meat. Bread can supply the missing carbohydrate, hence the value of the plebeian meal of bread and cheese. The fat it contains may render it indigestible, and some forms of cheese are more so than others.

Some of the cereal foods, *e.g.* white bread and rice, are almost completely absorbed, but the majority of vegetables leave a considerable residue in the intestine. This consists of the cellulose and some of the proteid constituents. The other constituents, *e.g.* water, fat, and carbohydrate, are almost wholly assimilated.

Vegetable proteid is less completely absorbed than animal proteid, but its heat value is fully as great.

The indigestibility of cellulose is in some respects an advantage, in others a disadvantage. The former lies in its promotion of intestinal action ; the latter in the fact that it may prove irritant to the alimentary tract, that it protects absorbable material from the action of the intestinal juices, and, while itself non-nutritious, that it occupies space which might otherwise be filled with valuable food ingredients.

The necessary supply of carbon is mainly derived from the sugars and starches of vegetable foods, while their fats are quite as efficient as animal fats.

One disadvantage of an exclusively vegetable diet is the bulk of it which would have to be ingested in order to supply the quantity of nitrogen required, not only for healthy existence, but for the output of energy.

Bread has too much carbohydrate and too little proteid to render it a veritable staff of life. Oats, despite their high nutritive value, may have the disadvantage of causing skin or intestinal irritation, the latter due to their cellulose, the former the so-called "heating" effect of oats. Maize is a valuable cereal, as the well-nourished frames of the mealie-fed Kaffirs of Natal can testify. The leguminous foods or pulses, including lentils, are very nutritious, but peas and beans have the drawback of producing flatulent distension.

DIETARIES.

Varying quantities of food are required according to age, sex, occupation, exertion, state of health, climate, and season.

During the period of growth and active procreative function, more food in relation to body weight, and especially more nitrogen, is required than is necessary in old age. In the latter the main function of the food is to maintain the heat of the body rather than to replace and build up tissue. In the young, on the other hand, growth has to be furthered, and heat has to be maintained. Consequently most food is required in the earlier years of life, and the proportion of nitrogenous food to the carbohydrates should be even greater than in the diet of the adult. As regards sex, females require less food than males, partly because their average body weight is less, and partly because they have less nitrogenous tissue to build up and less exertion to undergo. During lactation, however, an increased dietary is needed to meet the extra output. Hard brain work necessitates an ample, and especially an easily digested, animal dietary; while severe manual labour is best done when all the constituents of the food are freely taken, this being also the case when one indulges in active exercise. In a sedentary occupation the ingestion of carbohydrates and fats may, with advantage, be diminished.

The healthy body has to be fed, both as regards quantity and quality of food, on different lines from that which is the victim of disease. This aspect of the question, however, is rather clinical than hygienic. The inhabitants of cold climates require a greater bulk of food than do those living under temperate or tropical conditions. It is best taken in the compact shape of the fuel-forming fat. There is not a corresponding diminution in the diet of dwellers in the tropics, since they lose much heat by cutaneous evaporation.

In summer more fruits and vegetables and less meat, and in winter more fat and proteid, are indicated.

Average diet.—A healthy man of average weight (11 stones), doing a moderate amount of muscular work, excretes in the twenty-four hours about 20 grms. of nitrogen and 300 grms. of carbon. The avenues of excretion of the nitrogen are mainly the kidneys and intestines, of the carbon the respiratory system.

These amounts constitute the standard upon which his dietary is calculated. To supply this loss there would be required daily 125 grms. proteid, 500 grms. carbohydrate, and 50 grms. fat of water-free food. The heat value of this quantity of food constituents amounts to 3027·5 Calories. In addition, about 2 litres of water, apart from that present in ordinary solid food (50 per cent.), must be taken.

To ascertain from these figures of the proximate principles, the actual quantities of the food-stuffs corresponding, it is necessary to bear in mind the percentage composition of these latter, especially the amount of water they contain, and the proportion of their constituents which can be absorbed.

Now let us see what these quantities are in a mixed diet such as the following:—

Oz.	Food-stuff.	Proteid.	Carbohydrate.	Fat.	Salts.	Water.	Total.
		Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
8	Meat.	45·4	0·00	3·20	3·00	175·20	226·80
12	Potatoes.	6·0	72·85	0·35	3·00	258·00	340·20
16	Bread.	35·0	228·60	4·00	4·00	182·00	453·60
2	Butter.	0·57	6·57	47·07	2·83	5·66	56·70
1	Cheese.	9·0	0·35	7·40	1·10	10·50	28·35
½ pint	Milk.	8·52	14·40	11·36	1·88	248·00	284·00
2	Eggs.	7·9	0·00	6·74	0·56	41·50	56·70
2	Maizena.	0·28	48·20	0·00	0·17	8·05	56·70
2	Oatmeal.	8·50	38·00	4·53	1·14	4·53	56·70
		121·17	402·97	84·65	17·68	933·44	1559·75

Stating this diet in the form of meals, there would be allowed for—

Breakfast.—One soup plate of porridge, ¼ pint milk, 1 egg, 6 oz. bread, 1 oz. butter.

Dinner.—8 oz. meat, 3 potatoes, 4 oz. bread, 2 oz. maizena.

Supper.—6 oz. bread, 1 oz. butter, 1 oz. cheese, ¼ pint milk.

Note that beverages and condiments are not included, and that no deduction has been made for non-absorbability.

It will be seen, by reference to the table, that the carbohydrates are somewhat deficient, and the fat slightly in excess. This, however, is not a disadvantage, as one part of fat is equivalent to 2¼ parts of carbohydrate in fuel-forming capacity, though not in other directions.

The Calorie value of this diet is—$121{\cdot}17 \times 4{\cdot}1 + 402{\cdot}97 \times 4{\cdot}1 + 84{\cdot}65 \times 9{\cdot}3 = 496{\cdot}8 + 1652{\cdot}2 + 787{\cdot}3 = 2936{\cdot}3$ Calories, which approximates to what is required by a man doing moderate muscular work.

Translating this diet into the terms of carbon and nitrogen, it would supply 19·4 grms. nitrogen and 303·4 grms. carbon; the standard being, as will be remembered, 20 grms. nitrogen and 300 grms. carbon, that is to say, 1 of nitrogen to 15 of carbon.

As an example of how the calculations are made, consider first the proteid. We have 121·17 grms. of proteid in the diet. Now we know from its chemical formula that 6·25 grms. of albumin contain 1 grm. of nitrogen, hence if we divide our amount of proteid by this figure we obtain the amount of nitrogen present in it, namely, 19·38 or 19·4 grms. Further, we know that 1 grm. proteid contains about ·5 grms. of carbon, so that our carbon derivable from proteid amounts to 60·585 grms. The main source of our carbon is, of course, the carbohydrate; taking the formula of the latter as starch, $C_6H_{10}O_5$, we find that the carbon forms 44 per cent. This is because the molecule of starch is 162 ($12 \times 6 + 1 \times 10 + 16 \times 5$), of which the carbon represents 72, *i.e.* 44 per cent. of 162. The carbohydrate in our diet is 402·97 grms., and 44 per cent. of this is 177·3 grms. The fat also supplies a good quantity of carbon. Taking the fat as olein, $C_{57}H_{104}O_6$, and working out the sum in the same way as the carbohydrate, we find the carbon in the 84·65 grms. of fat to be 65·52 grms. Then the total carbon in the diet is $60{\cdot}6 + 177{\cdot}3 + 65{\cdot}5 = 303{\cdot}4$ grms.

It is necessary also to express the diet in terms of the foot-tons of energy which it is capable of supplying. This is done as follows. Various observations have shown that—

28·3 grms. of water-free albuminate	yield	173	foot-tons of potential energy.			
28·3 ,, ,,	starch	,,	138	,,	,,	,,
28·3 ,, ,,	fat	,,	378	,,	,,	,,

Apply these figures to our diet, and we find that—

121·17 grms.	proteid	yield	740·7	foot-tons	potential	energy.
402·97 ,,	carbohydrate	,,	1970·3	,,	,,	,,
84·65 ,,	fat	,,	1130·6	,,	,,	,,
	Total diet would	,,	3841·6	,,	,,	,,

A large part of this 3842 foot-tons is utilised for what is termed the internal work of the body, *i.e.* the circulatory and respiratory processes and the maintenance of heat.

De Chaumont considered that the internal work was equivalent to 2800 foot-tons of energy. Thus of our 3842, 1042 foot-tons remain. The human body, like a steam-engine, is not capable of transforming all this amount of potential energy into mechanical work, and, in fact, requires about five times as much potential energy in food as its output of mechanical work. Consequently our diet provides some 208 foot-tons of external work, and this represents a moderate muscular labour.

CALCULATION OF FOOD-STUFFS REQUIRED.

One is often asked to find from the amount of proximate principles of a standard diet the quantity of food-stuffs which must be taken to provide this amount of the proximate principles. This is a simple matter when the percentage composition of the food-stuffs and the nature of the standard diet are both known.

Example.—A standard daily diet for an average man doing moderate work is given as proteid 120 grms., carbohydrate 400 grms., fat 85 grms. What amounts of beef, bread, and butter must the man consume to provide this?

Let x = amount in grms. of beef required.
y = ,, ,, bread ,,
z = ,, ,, butter ,,

$$\text{Then } \frac{20}{100}x + \frac{8}{100}y + \frac{1}{100}z = 120.$$

The numerators represent the percentage proportion of proteid in beef, bread, and butter respectively (pp. 211, 213, 214).

So with carbohydrate—

$$\frac{50}{100}y + \frac{1}{100}z = 400;$$

and with fat—

$$\frac{1}{100}x + \frac{1}{100}y + \frac{83}{100}z = 85.$$

From these equations the values of x, y, and z are found to be respectively 278, 798, and 89 grms., or 9·8 oz. of beef, 28·2 oz. of bread, and 3 oz. of butter.

A diet which on paper yields so much proteid may not in reality possess such a quantity, as it is the custom to estimate proteid from the nitrogen obtained from the food on analysis, and to assume that all the nitrogen found has existed in the food in the form of proteid, which may not be the case. Further, some proteids contain more nitrogen than others, and thus the standard relation of 1 part of nitrogen in every 6·25 parts of proteid is not invariably accurate.

Again, a dietary calculated to yield so much proteid may by no means supply the body with such an amount of nitrogenous food, since there is nearly always a certain percentage of the proteid unabsorbed. This percentage is much less in meat and milk than in bread and potatoes. However excellent a diet may be, it should be varied from time to time, as a change is found very conducive to good health and keen appetite. Possibly this may be, because a sameness in the food tends to exhaust the manufacture of the particular juices required for its digestion, and so an alteration in the diet may bring about a corresponding change in the secretions. When it is impossible to vary the food itself, an advantage may be gained by cooking it differently.

COOKING.

Advantages.—(1) Complete or partial sterilisation of the food by heat,—for this a temperature of at least 70° C. is necessary, and it must be remembered that this is rarely attained in the centre of a piece of thick or rolled meat; (2) complete or partial inhibition of the deleterious action of ptomaines and their allies; (3) improvement in flavour (*e.g.* sugar being changed to caramel), and development of aroma; (4) prevention of putrefaction; (5) conversion of starch into a soluble form (amylodextrin),—chiefly seen in the case of vegetable foods.

Disadvantages.—(1) Loss of weight; (2) tendency to render proteid less digestible (overcooking); (3) tendency to render fat irritating by setting free of acids; (4) expense.

Methods.—*Boiling.*—Meat may be boiled for two objects—(*a*) to extract in whole or in part the soluble nutritive and flavouring materials, the soup or broth thus made being consumed; (*b*) to retain these materials in the meat, which is itself eaten. The former is accomplished by placing the meat in cold or tepid water, and raising the water nearly to the boiling point; the latter by first plunging the meat into boiling water so as to coagulate the myosin in its external layers, and subsequently gently boiling or simmering.

Vegetables are boiled to soften their cellulose and to facilitate the transformation of starch.

The effect of boiling milk is to sterilise it, but at the same time changes are produced in its constitution. The serum albumin is coagulated, the process beginning at 65° C. The carbonic acid is driven off, and consequently the lime salts may be no longer able to hold all the casein in solution, and accordingly a small portion of it may be found in the "skin" which forms on the surface when the boiling is conducted in an open vessel. The "skin" also contains fat, complete emulsification not being maintained at a high temperature. Further, both taste and colour are altered. Boiling does not deprive the milk of much nutrient material, but it renders the casein somewhat less easy of digestion. Milk, which is completely sterilised by steaming, as in Soxhlet bottles with rubber caps placed upright in the steam emanating from boiling water, undergoes the same changes as in boiling, but no "skin" is formed. To obviate the changes produced in colour and taste, while partial sterilisation is still secured, milk may be Pasteurised, *i.e.* kept at a temperature of 65° to 70° C. for half an hour. Such milk, however, will not keep for more than a few days, since the bacteria which produce souring are not destroyed. To destroy the spore-bearing bacteria of milk, such as those of the potato bacillus order, it is necessary to heat the milk to 100° C. for twenty minutes on each of three successive days, or to boil the milk at 120° C. for twenty minutes.

Eggs should not be boiled, as their albumin is thereby rendered hard and indigestible. They ought to be cooked at a temperature somewhat under 100° C.

Roasting has for its object the more complete retention of the extractives and nutriment of the meat, but is a more wasteful process than boiling, more weight being lost. Rapid coagulation of the external layers is produced, thus securing the above object, the roasting being begun at a high temperature, and continued at a lower one.

Stewing is a process of extracting the juices of meat at a temperature below the boiling point, and is best conducted in a water bath.

Frying is a process of rapid cooking in hot fat.

PRESERVATION OF FOOD-STUFFS.

This is required—(1) to destroy or arrest the development of micro-organisms which would render the food hurtful, remove its nutritive value, and deprive it of its attractive appearance; (2) to enable the produce of different parts of the world to be conveyed to other portions of the globe and there utilised; (3) to permit the produce of one season being used till that of another season is garnered.

Meat.—Apart from cooking, meat may be preserved by drying it in the sun's rays, a process only applicable where these are of sufficient intensity. The meat is cut into strips and hung up to dry, as in the case of the biltong of South Africa, the charque of South America, and the jerked meat of the American prairies. Meat may be mixed and rolled with its own fat, pressed and dried and supplemented by sugar, raisins, and currants, as in pemmican, which should contain 50 per cent. of fat. Meat may be smoked over wood fires, the desired effect being produced by the tarry products of combustion, or kept in strong brine, but a much more common process is salting. Immersion in brine is known as pickling, while in salting, common salt and nitrate of potash are rubbed into the fibres. Water and some of the nutritive qualities are lost in the process of salting. Meat may be kept in ice so that its temperature is at or near zero, but it is better to freeze the meat, and keep it frozen by refrigerating plant.

Refrigeration is a process now largely employed in the preservation and transport of meat. Ether, sulphurous acid, ammonia, or compressed air may be used in the refrigerating plant to secure the desired temperature. Another method is to exclude the air by providing an impervious surface layer, either by coating with flour, paraffin, or fat, or coagulating the surface albumin by plunging into boiling water; and yet another is to cut up the meat and heat it in a vessel, the mouth of which is afterwards tightly plugged with a germ filter, such as cotton-wool. A more extensive application of the latter method is the process of tinning. In this the tins are sealed in vacuo, or the air which they contain may be sterilised by heat (260° C.) or by steam. The air may be replaced by nitrogen and anhydrous sulphurous acid, or part of the air may be excluded, and the remainder treated by sulphite of soda to remove the oxygen. Preservatives may be applied to the surface, salt, sugar, charcoal, and various antiseptics being used.

Their action probably depends less on their antiseptic power than on the fact that they exclude air and in some instances keep off flies. Finally, the meat may be injected with preserving fluids or gases, such as solution of alum, salt, salicylic or boracic acids, carbonic acid or even carbon monoxide!

Fish may be cured by smoking and drying (marvis), and preserved by pickling, salting, mixing with oil and vinegar, canning, or by the addition of antiseptics, especially borax, boracic and salicylic acids.

Milk.—Apart from the heating processes already considered, milk may be dried to form a powder (plasmon or bumenol), concentrated to a syrup with or without the addition of sugar, tinned, or treated with antiseptics, such as formalin, benzoate of soda, bicarbonate of soda, boroglyceride, boracic or salicylic acid. Formalin is usually added in a proportion slightly higher than ten parts per 100,000. Condensed milks, being usually deprived of a portion of their fat, are not to be compared with fresh milk; and infants, pregnant women, and persons suffering from kidney disease should never be fed on milk containing preservatives.

Eggs.—An egg will keep longer if the air be excluded, and various plans have been tried to effect this, such as coating with gum, varnish, or butter, or placing the egg in lime water with tartrate of potash. Eggs should be stored in salt or sawdust.

Butter is usually preserved by salting it, but tinned butters are coming largely into use. The most efficient method, however, is to boil the butter till all water is driven off, and then strain it into a bottle, which is tightly corked, and in which the butter cools and solidifies, and will keep for a lengthy period.

Cheese.—Some soft cheeses may be preserved by hermetically sealing them in tins, as is done in France.

Flour and Meal are preserved by drying them, and the desiccation of bread is also practised, as well as the removal of its moisture by pressure.

Vegetables keep best when compressed, dried, and canned. Sulphate of copper has been used to preserve the colour of green vegetables, such as peas, the process being known in France as *reverdisage*.

Fruits are preserved in tins, and also dried with excess of sugar. In the case of both fruits and vegetables, canning is preferable to drying.

The report of the Departmental Committee appointed to inquire into the use of preservatives and colouring matters in food has been recently issued in the form of a Blue-book. The Committee make the following recommendations :—(*a*) That the use of formaldehyde or formalin or preparations thereof in foods or drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 gr. per pint in liquid food, and 1 gr. per pound in solid food, its presence in all cases to be declared; (*b*) that the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Acts; (*c*) that the only preservative which it shall be lawful to use in cream be boric acid, or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent., expressed as boric acid, the amount of such preservative to be notified by a label upon the vessel; (*d*) that the only preservative permitted to be used in butter and margarine be boric acid, or mixtures of boric acid and borax, to be used in proportions not exceeding 0·5 per cent., expressed as boric acid; (*e*) that in the case of all dietetic preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited; (*f*) that the use of copper salts in the so-called greening of preserved food be prohibited; (*g*) that means be provided, either by the establishment of a separate Court of Reference or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in food, and to prepare schedules of such as may be considered inimical to the public health.

UNSOUND FOOD-STUFFS.

The diseases which may be induced in man through the medium of food have been considered under the section of Medicine. Here we consider only unsound food-stuffs.

Meat may be derived from cattle suffering from actinomycosis, anthrax, dropsy, foot-and-mouth disease, indigestion, joint-ill, parasites, such as the *Cysticercus bovis*, cattle plague, rinderpest, pleuropneumonia, rabies, and tubercle. In Germany, calves are said to have suffered from a disease resembling enteric fever, and to have given rise to this disease in those who consumed their flesh. Sheep may be the victims of similar diseases, the best known being braxy and staggers. There appear to be two varieties of the former, one of which is due to the *B. anthracis*, and is also known as splenic apoplexy. The latter is caused by the *Cœnurus cerebralis*, a parasite which produces cerebral cystic disease. Sheep also suffer from the effects of the liver fluke, which causes "rot," and of the ova of *Strongylus filaria*, which produce the so-called "phthisis." Smallpox, pneumonia, and hæmaturia are also diseases of sheep, and render mutton unfit for food. What is called "black quarter" is a kind of spreading gangrenous erysipelas, probably a local anthrax, usually affecting a hind limb.

The diseases common in pigs are anthrax, swine fever, hog cholera, and numerous parasitic complaints, of which the most important are trichinosis and "measles," the latter due to the *Cysticercus cellulosæ*.

Horse-flesh may be rendered useless as food by reason of anthrax, glanders, and farcy.

Decomposition renders meat unsound, though the consumption of putrefying meat does not always give rise to ill effects if the meat be properly cooked.

It may be associated with the formation of dangerous ptomaines, which may also develop without any putrefaction being present, as when meat, whether cooked or not, is kept under non-hygienic conditions, and is exposed to sewer emanations. The flesh of animals killed by lightning or damaged by accident is unfit for human food, as is that of animals which have been dosed with large quantities of poisonous drugs, *e.g.* arsenic and antimony.

The flesh of fish may be unsound owing to parasites, such as *Bothriocephalus latus*, to ptomaine formation and decomposition. Shell - fish may be unfit for food, owing to their containing pathogenetic micro-organisms, and more especially the *B. typhosus*. They may also be rendered poisonous by exposure to sewage.

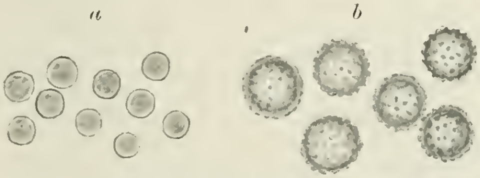


FIG. 65.—*a*, *Ustilago segetum* (smut); *b*, *Tilletia caries* (bunt), × 200 diameters.

EGGS too far advanced either in development or decomposition are unsound. MILK may be rendered unfit for human consumption by the changes induced in it by the acid-forming bacteria, the presence of the *Oidium albicans*, various fungi and moulds, and by the fact that it may contain pathogenetic micro-organisms, *e.g.* those of tubercle, enteric fever, cholera, scarlet fever, and diphtheria, some of which have been known to reach milk through the medium of water with which it had been diluted.

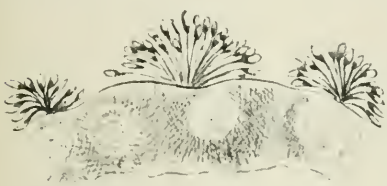


FIG. 66.—*Puccinia graminis*.

Milk may contain toxic principles from drugs or poisonous plants ingested by the animal yielding the milk, or added to it as preservatives or colouring matter. Decomposition of the proteid of milk may result in the formation of a poisonous body called tyrotoxicon. Milk is unsound if drawn from an animal suffering from mastitis, cattle plague, foot-and-mouth disease, or tubercle. Condemnation would likewise be necessary if scarlet fever, diphtheria, and enteric fever were definitely proved to be diseases from which cows suffer.

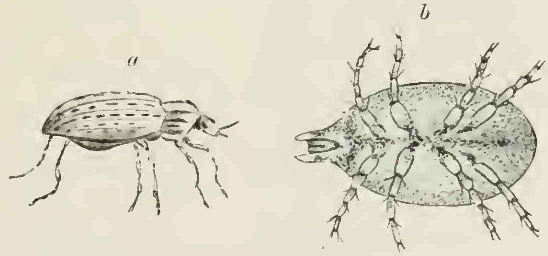


FIG. 67.—*a*, *Calandra granaria* (corn weevil), × 4 diameters. *b*, *Acarus farinæ* (meal mite), × 100 diameters.

MILK - BORNE EPIDEMICS.—From the observations of Power and others, the characteristics of such epidemics have been shown to be—(1) Sudden outbreak, and rapid diminution of cases on stoppage of the infected milk supply. (2) Simultaneous attacks. Rapid attainment of the maximum number of cases, owing possibly to the limited period of milk infectivity. (3) Multiplicity of infection in house inmates; but milk scarlatina is not very communicable from person to person. (4) Ratio of attacks to infected households high. (5) Households affected obtain milk from a common source, though possibly through different vendors. (6) The ratio of households supplied from the common source and attacked, to households supplied from the common source is greater than the ratio of total households attacked to the total number of inhabited houses in the district. (7) Most attacks in households consuming most milk. Therefore wealthier classes suffer (Cooper). (8) Attacks most common amongst persons drinking much raw milk. (9) Incidence heavier on women, children, and young adults. (10) As regards scarlet fever, the epidemics are mild, with a low case mortality. (11) Keeping overnight renders infected milk and cream more virulent.

Fig. 68.—Spurred rye.

Butter may become unsound from the decomposition of its fat with the liberation of irritating fatty acids, or, like milk, it may contain tyrotoxicon. Evidence as to butter containing pathogenetic microbes, such as tubercle, is inconclusive.

Cheese may decay to such an extent as to be unfit for food, and in it also tyrotoxicon may develop. It may be poisonous, owing to the addition of copper and arsenic, the rind in this case being especially harmful. Sour cheese should not be eaten.

Flours and Meals may be damp, sour, or mouldy, and may contain bacteria, fungi, such as smut (*Ustilago segetum*) (Fig. 65, *a*), rust (*Uredo fœtida*), the spores of which are yellow, bunt (*Tilleties*) (Fig. 65, *b*), and mildew (*Puccinia graminis*) (Fig. 66). The fungi which are the causes of pellagra and lathyrism may be present in flours made from maize and chick-pea respectively. Weevils (Fig. 67, *a*), acari (Fig. 67, *b*), and the ear cockle (*Tylenchus tritici*) may also be present, while ergot is common in rye and not unknown in other flours (Figs. 68, 69, 70).

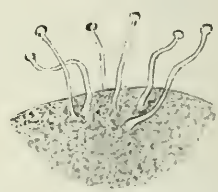


Fig. 69.—*Sclerotium* and *Stromata* of *Claviceps purpurea*.

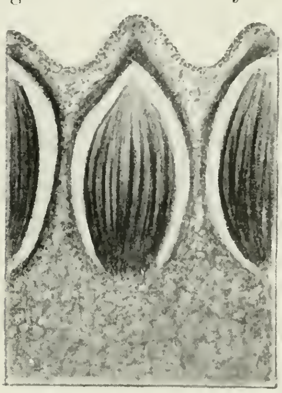


Fig. 70.—Ergot of rye (*Ascocarps* and *Asci*), ×350 diam. (After Pakes.)

Bread may be acid if made from old or imperfectly dried flour; it may be contaminated with fungi, or adulterated by excess of alum, the former causing diarrhœa, the latter probably inducing dyspepsia and constipation.

Bread, as has been stated on p. 121, may contain lead, and the presence of darnel seeds (*Lolium temulentum*) may render it poisonous. Rice may harbour a fungus supposed to be the cause of beri-beri. Potatoes may suffer from wet rot, a bacterial disease which renders the affected parts useless as food; and potatoes which have been frozen rapidly decompose on thawing, and cannot be used after decomposition has set in. Peas may contain the *Bruchus pisi*, a form of parasite allied to the weevil. Peas, beans, and other green vegetables may have to be condemned owing to the presence of sulphate of copper. Preserved vegetables may absorb metallic poisons, such as copper, lead, tin, and zinc, from the tins in which they are canned, as fermentation may provide the necessary acid for the solution of the metal.

PREVENTION OF DISEASED ANIMALS BEING USED FOR FOOD.

Since cattle suffering from tuberculosis may present no obvious symptoms, the value of a test to detect those infected cannot be overrated. This test is the injection of tuberculin, a substance obtained from the growth of the tubercle bacillus in artificial media. Cattle, the victims of tuberculosis, react to this test, the reaction being shown by a rise of temperature within twelve hours of the injection. The normal rectal temperature of cattle is about 102° F., and a rise of 2·5° is common in tuberculous animals after injection. Animals which have been tested will not again react within a month. The Royal Commission on tuberculosis (1898) recommended that stockowners should be encouraged to have their animals tested, by the offer of a gratuitous supply of tuberculin and the gratuitous services of a veterinary surgeon.

INSPECTION AND EXAMINATION OF FOOD-STUFFS.

Meat.—The medical officer of health will always find it useful to have a practical knowledge of meat inspection, even if it only secures for him the respect of his subordinates, to whom the art more particularly appeals. It is quite impossible to treat of the subject at any length, but an endeavour is made to set before the reader those points of most importance to a medical officer. A carcase should always be hung up when it is to be inspected, so that every part of it is visible and its natural shape preserved.

With regard to fresh *cattle carcases*, one has to consider—(*a*) their age; (*b*) sex; (*c*) whether fit or unfit for food; (*d*) the tricks of the trade.

(*a*) Age.—*Young.*—Bones soft, porous, smaller, and vascular. Inner aspect of ribs (thirteen pairs) pink. Joint cartilages also pink. There is much gristle at the joints, and it is best seen at the pubic junction, where it is of a bluish colour. It ossifies at the age of 6 years. Teeth (permanent)—two at 2 years, four at 3 years, six at 4 years, and eight at 5 years. Flesh firm, bright red after exposure to air, juicy, but not too moist, smooth and satin-like to the touch, well marbled with fat, especially in the loin. Fat firm, paler, plentiful.

Old.—Bones hard, dense, larger, non-vascular. Inner surface of ribs white and shiny. Gristle less well-marked at joints, and absent at pubic junction (no bluish colour). Teeth worn. Flesh stringy, tough, not so elastic, rougher to the touch, and less marbled with fat. Fat yellower, less plentiful, and has a shrunken look.

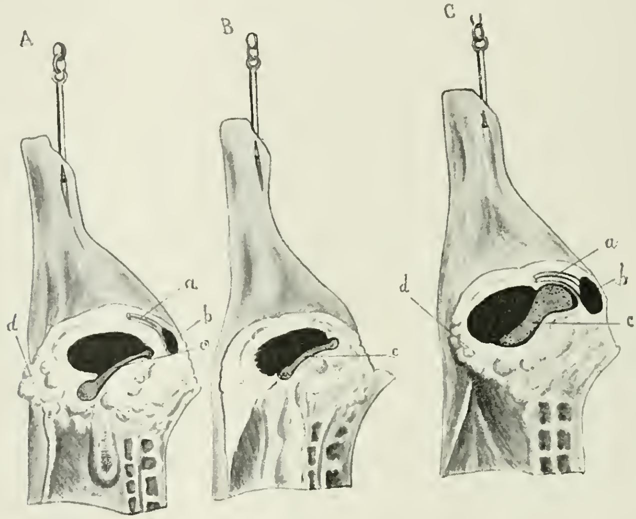
(*b*) Sex.—*Male.*—*Bull* (Fig. 71, *c*).—Bones massy, especially the aitch or pelvic bone. More muscle generally, crest or collar large and muscular, muscle coarser and not marbled with fat. Pizzle present and large, inguinal canal in evidence, erector muscle well marked. Little cod (scrotal), kidney, or subcutaneous fat. The same characteristics in a minor degree are owned by the bull "stag," *i.e.* an animal castrated imperfectly or late in life. The fat of a young bull is whiter than that of a young ox, but the colour of the fat is influenced by the feeding.

Ox (Fig. 71, *a*).—Bones slighter, crest small, muscle smooth, juicy, and marbled in the young animal. Pizzle thinner and smaller, inguinal canal present, erector muscle less broad. Cod, kidney, and subcutaneous fat plentiful, the last-named freely coating the shoulder.

Heifers (Fig. 71, *b*).—A maiden heifer (or cow which has had no calf), a heifer (or cow which has had not more than one calf), or indeed any cow which has had no more than two calves, rarely appears as meat.

The chief point to be noted in their carcases is that the udder consists of a smooth, olive-shaped mass of fat, which contains less spongy tissue the younger the animal.

Old cow.—Aitch bone characteristically thin, hard, and white; muscles dark, dry, stringy, and coarse to the touch, fat scanty and very yellow as a rule. Large pelvic cavity. Scapulæ prominent, and their muscles atrophied.



Ox Heifer. Bull.

FIG. 71.—*a*, Pizzle. *b*, Retractor muscle. *c*, Aitch bone. *d*, Cod fat.

(*c*) UNFITNESS FOR FOOD.—Observe colour of flesh. Dark meat may indicate inflammation, damage due to accident, or imperfect bleeding, in all of which cases it is best condemned. A dark colour, combined with dryness and harshness, usually indicates that the animal has met its death by some other means than the pole-axe or the cartridge. Any bad odour should at once lead to the condemnation of meat, and a knife should be plunged into the fleshy parts, withdrawn and smelt.

Marasmus and chronic disease of the internal organs are evidenced by pale, soft, and dropsical flesh, which offers no firm resistance to the impacting fist. Actinomycosis is to be looked for in the lower jaw, tongue, gullet, and stomach. White nodules are very characteristic, and there may be abscesses containing pus with the typical granules. When an animal has died of anthrax, the blood is fluid and dark-coloured; the spleen, kidney, and liver are gorged, and there may be hæmorrhages in the muscles, fasciæ, and internal organs. The flesh has a soapy feel, an offensive odour, and is soft, owing to the absence of post-mortem rigidity. The post-mortem appearances in blood-poisoning and malignant œdema resemble those found in anthrax, and a microscopical examination is required. The mouth, feet, and udder should be inspected in cases of foot-and-mouth disease, and any affected parts destroyed. The flesh, as a rule, is good enough. Parasitic diseases, such as cysticerci and trichinæ, must be looked for; the former appearing as small cysts, the latter as tiny white or grey specks. If calcification has taken place, the knife rasps upon the meat. Commencing putrefaction is indicated by pallor, smell, and softening. When more advanced, the colour is green. To bring out any odour which may be present, it is often well to cut up the meat and soak it in hot water. The condition of the bone-marrow is an important guide to the freshness and health of a carcase. The normal marrow is firm and rosy red; when putrefaction has commenced, it becomes soft and brown.

A dark and sticky meat indicates that the animal has been slaughtered while suffering from milk fever. While the flesh of animals suffering from the early stages of inflammatory disease has not been shown to be dangerous, and while opinions vary as to the toxicity of meat derived from cattle suffering from rinderpest, there can be little doubt that such meat should not be sold as food, at any rate without previous sterilisation.

Note the pleura, whether present or absent. In the latter case, look for further evidence of tubercle or pleurisy. If present, observe whether it is smooth and shining, as in health; red and blood-stained, as in pleurisy and pneumonia; grey, yellow, or nodular (*perlsucht*), as in tubercle.

Adhesions indicate some form of pulmonary complaint. If tuberculosis is suspected, incise the breast-glands which lie between the fourth and fifth ribs. Should these present small white nodules, tubercle is proved, their normal colour being pale brown. Examine the peritoneum, which should be smooth, glistening, and free from adhesions. Any stripping of the peritoneum from the under surface of the diaphragm is a suspicious sign. If possible, the internal organs, especially the lungs, liver, spleen, and kidneys, should be inspected. The two former are frequently the seat of tubercular disease. The brain may be tuberculous, and in the cow the udder is very often diseased. The tubercle bacillus has been demonstrated in the blood and muscle juice, and in the secretions of the diseased organs, while the flesh may easily become infected through the agency of a knife which has been used to cut up parts that are the seat of the disease. The question of the transmission of bovine tubercle to man by means of infected meat is one of great moment, so much so that the Royal Commission (1896–98) reported on the subject, recording their view that tuberculosis is transmissible to man from the use of cattle and their products as food. Still more recently, Professor Koch astonished the scientific world by declaring that the result of his experimental investigation showed that bovine tuberculosis is a disease distinct from human tuberculosis, and that cattle and swine cannot be infected with human tuberculosis. Further, he asserts the rarity of primary intestinal infection in human beings; and from this, and from a consideration of the results of his experiments, he concludes that the transmission of tubercle to man in the meat and milk of tuberculous cattle is so rare an event that it is not necessary to take special precautions for its prevention. British, American, and German commissioners are now investigating the subject in their several countries; and, so far, British authorities do not agree with Koch's views on this matter.

Primary intestinal tuberculosis is not rare in this country, and it has been estimated that in children some 30 per cent. of all tubercular lesions begin in the alimentary tract. Until the conclusions of the new Commission are published, the recommendations of the Royal Commission (1896–98) should be enforced in dealing with tuberculous meat. These are as follows:—

(α) The entire carcase and all the organs may be seized if there be—(1) Miliary tuberculosis of both lungs; (2) tuberculous lesions of pleura or peritoneum; (3) tuberculous lesions of muscular tissues or of lymphatic glands embedded in or between the muscles; (4) tuberculous lesions in any part of an emaciated carcase; (5) stripping of the pleuræ in any carcase imported from abroad.

(β) The carcase, if otherwise healthy, shall not be condemned, but every part of it containing tuberculous lesions shall be seized, when—(1) Lesions are confined to the lungs and thoracic glands; (2) lesions are confined to the liver; (3) lesions are confined to the pharyngeal lymphatic glands; (4) lesions are collectively small in extent, though present in more than one of these regions.

They also recommend that the notification of every disease in the udder shall be compulsory, whether the milk of the animals is offered for sale or not, and that the powers of local authorities to exclude the milk of tuberculous animals should be extended.

(*d*) Tricks of the Trade.—In the inspection of meat, care must be taken to discover any frauds, such as the endeavour to pass bull or old cow meat for prime ox beef, or old cow meat for heifer meat. Such frauds are—(1) Removing the testicle from the hind quarter of a bull and stuffing the cavity with fat, in order to make the cod fat like that of an ox. (2) Splitting the pizzle and partly removing it in order to make it the same size as that of an ox, or taking it out entirely and leaving the retractor muscle. (3) Removing the crest of a bull carcase to make it simulate ox beef. (4) Removing the udder of an old cow while the carcase is warm, and fixing the skin over the excised part. The skin may be skewered in rolls, so as to resemble the udder of a heifer or the cod fat of an ox. Other attempts at fraud may consist in stripping the pleura and diaphragmatic peritoneum of tuberculous animals, or the substitution of horse-flesh for that of cattle.

In this connection it is well to remember that the horse has eighteen pairs of ribs, and the ox but thirteen; further, that horse-flesh, which under certain restrictions as to its sale is permitted to be used as human food, has a darker colour and less pleasant odour than ox flesh, that its fat and its marrow are oily, that its bones are larger, and the femur has a third trochanter. The tongue of the horse differs from that of the ox.

Refrigerated Meat is as a rule excellent, and may be distinguished from fresh meat by the fact that the pizzle and root are always absent, the joint gristle at the pubis is pinkish instead of bluish, and the fat is also pink, being stained by the juice of the lean, which is itself pale and somewhat brick-coloured. The carcase is cold, stiff, and lacks lustre, the vertebræ are sawn instead of chopped through, and there are usually three ribs instead of one in the hind quarter. On removing the cloth with which the meat is covered, there may be a slightly unpleasant smell, but this of itself should not cause rejection of the meat, as it may be confined to the surface, being merely due to the cloth.

Frozen Beef, both lean and fat, is cold and hard before being thawed. After thawing it is wet and oozing, and the fat is deadly white and unstained, while the flesh has a uniform pink appearance. The carcase is cut up before freezing, and thus loses in nutritive value.

Salted Meat.—If the salting has not been properly done, putrefaction may be observed in parts of the meat; and if the meat has begun to decompose before being salted, the firm consistence of salted meat is absent. Samples for inspection should be taken from every part of the cask, and if the meat be extremely hard and tough, it has probably been derived from aged animals.

Tinned Meats.—The exterior examination of the tin may reveal that the meat is unfit for food. The tin may be found leaking, bulged by the pressure of gas from decomposition of its contents, or giving off an offensive odour. If a tin yield a hollow sound when struck by a wooden mallet, it either contains gas or has not been fully filled before sealing.

Mutton.—As regards the distinction between old and young animals, and between rams, wethers, and ewes, much the same points apply to fresh mutton as to fresh beef. The age, however, may be conveniently told by the appearance of the intercostal spaces when viewed from the back. The darker these are, the older the animal.

Sheep's flesh has not such a rich red hue as that of beef, and its fat is very white, and has a higher melting-point than beef fat. Mutton is often too fat, and in such a case the layers of fat entirely obscure the lean which should be visible over the shoulder blades.

Mutton may be rendered unfit for food by similar conditions to those which disqualify beef, and must be examined for such signs as stripping, adhesions, etc. The flesh of a sheep which has died from rot is œdematous and unfit for human food. If there are only a few flukes in the liver, the flesh may be unaffected and wholesome. Mutton from an animal emaciated as the result of staggers should not be eaten, and if at all suspicious the brain should be examined.

Frozen Mutton.—The carcases of sheep are, as a rule, frozen whole, and consequently the meat is relatively more nutritious than frozen beef. The deeper parts, however, may be imperfectly preserved, and for thorough inspection incisions into the fleshy part of the thigh may be necessary.

Pork.—As pigs are very liable to disseminated tubercle, the Royal Commission recommended that the least trace of tuberculosis in a pig should lead to condemnation of the whole carcase. In a pig which has died of swine fever, the skin, fasciæ, and muscles present patches of redness, and the flesh may be œdematous, and must be condemned. The special lesions are ulcers in the large intestine, and inflammatory exudations in the lungs, liver, and lymphatics. Pork must always be carefully examined for evidence of parasitic diseases. The flesh of parturient animals is sometimes good, sometimes bad, depending largely on the manner in which the animal has died and the length of the labour.

Drugged animals.—Any odour of the medicine from the flesh suffices to condemn it.

Sausages.—When unfit for food owing to putrefaction, sausages have a bad ammoniacal smell, which is intensified by boiling them with lime water.

Rabbits frequently suffer from psorospermosis, which causes hepatic nodulation and discoloration, but does not necessitate condemnation of the flesh.

Fowl.—Fowls suffer from tubercle, but avian tubercle bacilli are not identical with those of human tuberculosis, and there is no proof that the flesh of tuberculous fowls, when ingested, can give rise to tubercle in man.

To prevent the substitution of diseased meat for that which has been passed by the inspector, it is recommended that the inspector should stamp all joints which have not been condemned. To obviate the waste of all meat which has been condemned, and to provide cheap and not unwholesome meat to the poorer classes, it is the practice in Germany to treat meat not itself diseased, but derived from tuberculous carcases, in a Freibank or public kitchen, where it is heated in cylinders up to 100° C., and thus thoroughly cooked. As an alternative, it can be sterilised by steam under pressure. Meat that is quite unfit for human food may be utilised for manure, care being taken to prevent the dissemination of tubercular virus during its removal from the slaughter-house.

Microscopical examination of meat.—Beef is to be examined microscopically for the *Cysticercus bovis*, which is found between the muscular fibres, and measures from 2 to 5 mm. in length. It contains the scolex, which is visible under the low power and presents a miniature head and neck of the *T. mediocanellata.*

The measle of beef must not be confounded with psorospermia or Rainey's capsules, which are small cysts filled with granular matter, and are harmless to man. Microscopic examination of pork is necessary for the detection of *Cysticercus cellulosæ* and encysted trichinæ. The former are 3 to 4 mm. in length, and are little clear cysts with well-defined margins. Brief clearing of the muscle fibres with liquor potassæ will usually reveal any capsulated trichinæ which may be present, and the worm can be seen coiled up within the capsule, the long axis of which is parallel to the muscle fibre. They are to be looked for in the diaphragmatic and intercostal muscles, and those of the eye and jaw. Both these conditions must be distinguished from Rainey's capsules, which are common in swine flesh. The juice of frozen meat may be recognised microscopically by the fact that the red blood corpuscles are decolorised and distorted, while the surrounding fluid is dark. The corpuscles are normal in the juice of fresh meat, and the surrounding fluid is colourless.

Fish.—Commencing putrefaction in a fish is evidenced by its dull and sunken eyes, the softness of its flesh, which pits on pressure, and the drooping of its tail when the fish is held horizontally.

Eggs.—Note the smell, since sulphuretted hydrogen is produced as the result of decomposition. The freshness of an egg may be determined by placing it in a 10 per cent. saline solution. If perfectly fresh it will sink, but if stale it will float more or less near the surface, owing to loss of water by evaporation.

Milk.—It is important that the inspector should know under what category the milk in question is offered for sale, whether fresh, skim, or separated.

Standard Composition.—Empowered by section 4 of the Sale of Food and Drugs Act, 1899 (p. 542), the Board of Agriculture has recently fixed a standard composition for fresh milk. Samples which do not come up to this standard render their vendors liable to prosecution. Should such milk contain less than 3 per cent. of fat, it is presumed that the milk is not genuine, and that either fat has been abstracted from it or water added. If the total solids in such a sample are less than 8·5 per cent. (not including the fat), it is presumed that the milk is not genuine, and that either solids other than the milk fat have been abstracted from it, or water added. If a sample of skimmed or separated milk, not being condensed milk, contains less than 9 per cent. of milk solids, it is presumed that the milk is not genuine, and that milk solids other than milk fat have been abstracted therefrom or water added.

Physical Examination.—*Clarity.*—Milk should be opaque.

Colour.—It should be a rich "thick" white, approaching yellow rather than blue.

Smell.—Good milk should have a "creamy" odour.

Taste.—Milk should possess a taste whose blandness approaches an actual want of taste. Any sourness indicates that the acid-forming bacteria have had time to decompose the lactose. Perfectly fresh and good milk kept under non-hygienic conditions may acquire a bad taste even before turning sour, as milk has a special facility for absorbing organic vapours and odours.

Suspended matter and sediment.—On standing, the larger proportion of the fat of milk rises to the surface as cream, and its amount is determined by observing the quantity of cream which collects if the milk be allowed to stand in a graduated glass for twenty-four hours. There should be at least 1 part of cream to 17 parts of milk, and there may be as much as 1 part of cream to 3 parts of milk, the amount varying with the season, feeding, breed of cattle, etc. During the time the cream rises, a sediment forms composed of dust, epithelium, hairs, etc., which under ordinary conditions it is impossible to avoid. Such substances as chalk, starch, and flour, which may have been added to the milk, will increase the sediment.

Chemical Examination.—*Reaction.*—The milk of herbivorous animals when fresh usually has an amphoteric reaction, due to the presence of acid phosphates of the alkalies. Marked acidity is usually caused by the presence of lactic or butyric acid, the result of bacterial action, while alkalinity may be dependent on certain other bacilli, or an alkaline preservative such as sodium bicarbonate.

Specific gravity.—The specific gravity of milk varies from 1030 to 1034. It must be taken at 15° C. or corrected to that temperature, since by raising the temperature of milk its specific gravity is lowered. For every 6° C. rise of temperature the specific gravity falls one degree. The removal of fat from milk results in raising its specific gravity, owing to the removal of its lightest constituent. On the other hand, the addition of water lowers the specific gravity. Every 10 per cent. of water added entails a loss of 3° of specific gravity at 15° C. Consequently it is a common fraud to doubly "doctor" a milk by removing its fat and at the same time adding water, so that its specific gravity remains unchanged. Taken by itself, the mere determination of the specific gravity yields little information, but when combined with the estimation of total solids and fat, useful deductions can be drawn from it.

The specific gravity may be gravimetrically obtained by means of a specific-gravity bottle; more usually a lactometer, which is a special form of hydrometer, is used.

Preliminary to any testing of milk, the sample should be well shaken.

Total solids.—These are determined by slowly evaporating a given quantity of the milk, drying and weighing the residue. Care must be taken that there is no charring, and that the process is not hindered by the "skin" of serum albumin which forms on the surface. The solids are stated as a percentage, a good average being 12 per cent.

Ash is estimated by incinerating the total solids and weighing the residue. It should not be less than ·7 per cent. of the milk, and therefore should constitute nearly 6 per cent. of the total solids. Watered milk is deficient both in total solids not-fat and in ash. A separated milk is deficient in total solids owing to the removal of fat. The ash is increased if the milk has been adulterated with chalk, sulphate of lime, or calcium carbonate or bicarbonate.

Fat.—This may be determined in various ways, the outlines of which are here given—

1. The fat is collected by various devices on a fat-free filter paper, from which it is extracted by means of ether, and weighed in a tared flask after evaporation of the ether. It is stated as a percentage of the total milk. This is the basis of the processes of Adams, Gerber, and Soxhlet.

2. The Werner-Schmidt method consists in boiling the milk with strong hydrochloric acid in a special tube, so as to destroy the emulsification of the fat. Thereafter the freed fat is dissolved by ether, and a definite quantity of the solution is taken, the ether evaporated, and the fat weighed. From this the total fat extracted by the ether is calculated and stated as a percentage of the milk from which it has been obtained.

3. Centrifugalising, in a graduated vessel after liberation of the fat (Leffmann and Beam), or in test tubes fixed to a revolving disc (Gerber's mechanical method).

Good milk contains about 4 per cent. of fat, and should never have less than 3 per cent. By deducting the fat from the total solids, the total solids not-fat are obtained; these are remarkably constant, and should not be less than 8·5 per cent.

4. The fat, instead of being estimated experimentally, may be calculated from the specific gravity and total solids by means of the special formula of Hehner and Richmond, which, for convenience of remembrance, may be stated as follows:—

$$F. = \cdot 86\ T.S. - \cdot 22\ G,$$

Where F. = fat, T.S. = total solids, and G. = specific gravity − 1000.

This formula is only suited to average milk, and requires modification for very poor milks or milks very rich in fat. Richmond's slide rule enables one to apply a somewhat similar formula in a mechanical manner. It consists of three scales, respectively the Sp. gr., T.S., and Fat.

The first is a sliding scale, the other two are fixed so that if any one factor be known, and the rule adjusted accordingly, the others can be read off. The corresponding formula for finding total solids from fat and specific gravity is—

$$T.S. = 1 \cdot 2\ F. + 0 \cdot 14 + 0 \cdot 25\ G.$$

5. By the lactoscope. This is an instrument by which the fat is determined from the opacity of the milk, the distance at which a candle flame can be seen through the milk being noted.

There are two varieties, in one of which the instrument is moved towards the flame or removed from it; in the other the distance is fixed, and the milk is diluted with water until the flame can be seen through it.

The corresponding amount of fat in either case is obtained from tables. Instead of the flame a white surface with black horizontal lines marked upon it may be put into a graduated tube containing the milk, which is diluted till the lines can be seen and counted through it. The amount of fat is obtained from the final reading on the graduated tube.

Proteids.—The casein and the lactalbumin may be estimated either separately or together. In the former case a precipitate is obtained by boiling with acetic acid, and is then washed with ether, dried and weighed, and the casein is calculated as a percentage. The lactalbumin can be measured, after the casein has been removed, by means of rennet and filtration; the whey is treated with alcohol, and the precipitated albumin washed with ether and alcohol, dried and weighed. In the latter case, copper sulphate and caustic potash are employed to precipitate all the proteid as copper albuminate. This is collected on a fat-free filter paper, the fat removed by ether, the albuminate weighed, and the albumin calculated (Ritthausen).

Another way is the albuminoid ammonia process as applied to water, all the proteid being calculated as casein, and ·065 parts of ammonia representing 1 part of casein.

The total proteid should be between 3 and 4 per cent.

Richmond's formula may be used for finding the proteid when the specific gravity, total solids, ash, and fat are known—

$$P. = 2{\cdot}8\ T.S. + 2{\cdot}5\ A. - 3{\cdot}33\ F. - 0{\cdot}7\ \frac{G}{D},$$

Where P. = proteid, T.S. = total solids, A. = ash, F. = fat, G. = specific gravity − 1000, D. = specific gravity at 15° C., when that of water is considered as unity.

Sugar.—The lactose may be determined (*a*) by a saccharometer, or (*b*) by a solution of copper, the proteid and fat being first of all removed.

(*a*) The principle of the saccharometer depends on the rotation of polarised light by sugar. Lactose is dextro-rotatory, and it is estimated from the degrees of angular rotation produced, or the saccharometer may be graduated so as to express the percentage of sugar directly in terms of cane sugar. (*b*) The filtered whey which remains after the milk has been subjected to the methods of Ritthausen and Soxhlet for the removal of proteid and fat, is treated with Fehling's solution, of which 10 c.c. = ·067 grm. of lactose. From the amount of the whey required to reduce the cupric tartrate to red suboxide of copper, the amount of lactose in the whole whey, and consequently in the original milk, can be calculated.

It is stated as a percentage, and should reach 4 to 5 per cent.

Microscopic Examination (Plate VI. Fig. 6).—Both the milk and the cream should be examined microscopically. Milk exhibits a number of highly refractile fat globules of various sizes, and if the serum film be thin there may be a few leucocytes visible in the field, while there is usually a little epithelium. Colostrum corpuscles are seen in the milk drawn from a cow within three days after parturition. Epithelium, pus-cells, streptococci, and bacilli are found in the milk of animals suffering from mastitis. Granules of starch, fragments of chalk, and other adulterants, may be present in impure milk. Fig. 72 shows the appearance presented microscopically by a sample of milk obtained from a town dairy and centrifugalised.

Bacteriological Examination.—This may be either qualitative or quantitative. Milk as secreted from the udder should be sterile, but very early in its journey bacteria find a lodgment in it, for the milk in the teats, forming the residue of a previous milking, swarms with micro-organisms.

From the udder surface, from the milking hands, from the byre dust and air, from pails and vessels and the water used to wash them, bacteria may reach the milk. Further, water added as a diluent may convey germs to the milk, and not uncommonly those of a pathogenetic nature. The species of bacteria most frequently found in milk are *B. actinobacter*, *B. butyricus*, *B. coli communis*, *B. distortus*, *B. fluorescens liquefaciens*, *B. filiformis*, *B. lactis*, *B. mesentericus vulgatus*, *Proteus vulgaris*, *B. subtilis*, and coccal forms. Of other less common kinds there are *B. cyanogenus* (blue milk), *B. prodigiosus*, *B. lactis erythrogenes*, and *Sarcina rosæ* (red milk), *B. synxanthus* (yellow milk), two forms of bacilli described by Guillebeau in ropy milk and the *B. viscosus* of viscid milk.

Fig. 72.—Milk from town dairy. (Centrifugalised.) × 1000 diameters.

Offensive smelling milk may contain the *B. fœtidis lactis*, while varieties of fungi, *e.g. Oidium lactis*, are not uncommon.

The most important of the pathogenetic micro-organisms is that of tubercle, which may be present in the milk when it leaves the cow if the animal suffers from tubercular disease of the udder or teats, and in rare instances if there be general tuberculosis. The demonstration of the tubercle bacillus in milk is no easy matter, and it is best to add carbolic acid to the milk. This gets rid of some of the other organisms, and causes a precipitate in which the tubercle bacillus may be found. Another way is to repeatedly centrifugalise the milk, remove the fat, and obtain a sediment in which the bacillus may be stained.

A more tedious method is to inject some of the milk, or the sediment after centrifugalisation, into the peritoneal cavity of a guinea-pig, kill the animal after four weeks, and examine the peritoneum for evidence of tubercle. The *B. typhosus*, the vibrio of cholera, the *B. diphtheriæ*, the *B. enteritidis sporogenes*, the *Streptococcus scarlatinæ*, and the *B. anthracis* have all at times been found in milk. Löffler's bacillus is said, however, to live only a short time in milk, and to rapidly lose its virulence.

For the quantitative examination of milk it is necessary to greatly dilute the specimen with sterile-distilled water. We have found as many as

6,000,000 colonies per c.c., and 500,000 per c.c. is a fair average, much depending on the age of the milk.

Detection of Adulterations of Milk.—If the milk has only been watered, analysis will show a low specific gravity and a diminished amount of fat, total solids, and ash. Creaming alone will produce a high specific gravity and a diminished amount of fat and of total solids. Watering and creaming combined may leave the specific gravity normal, but all the constituents and especially the fat are diminished. The percentage of water added may be obtained if the normal and the observed quantities of ash be known. Thus, if A be the normal ·7 per cent. and a the observed quantity of ash, the percentage of water added $= 100 - \frac{100\,a}{A}$. From the solids not-fat a similar calculation can be made, if $S =$ the standard 8·5 per cent. of solids not-fat, and $s =$ the observed quantity of these solids, then the percentage of water added is $100 - \frac{100\,s}{S}$.

The addition of skimmed milk to fresh milk causes the latter to have rather a high specific gravity, scarcely changes the amount of water, diminishes the cream, and greatly lessens the fat. If the adulterated milk be now skimmed it will have a specific gravity about the normal.

The addition of water and skimmed milk to fresh milk gives a low specific gravity, increases the amount of water, and diminishes the fat and cream. If the adulturated milk be thereafter skimmed it will have a low specific gravity.

The addition of sodium bicarbonate may be detected in the ash by treating it with an acid, when effervescence will betray its presence. Boiling the milk for an hour will render it brown if sodium bicarbonate be present.

Formalin often causes an increase in the amount of total solids, and may be detected by dilution of the milk and the addition of slightly diluted commercial sulphuric acid, which contains a trace of iron. A purple ring forms at the junction of the two liquids. Another test consists in adding to 10 c.c. of the milk 2 c.c. of 10 per cent. caustic potash and 2 c.c. of a ·1 per cent. aqueous solution of phloroglucinol, the formalin striking a pink colour. These tests will not answer if several days have elapsed since the preservative was added to the milk. Chalk may be found in the deposit of milk to which it has been added. The deposit is washed, treated with acetic acid and filtered; then oxalate of ammonium is used to precipitate the lime as oxalate. Borax or boracic acid may be detected in the ash by treating it with hydrochloric acid, evaporating and dissolving in hot water. With this solution a piece of turmeric paper is moistened and allowed to dry, and if borax or boracic acid be present the paper becomes a ruddy colour. Salicylic acid gives a violet colour with ferric chloride. The milk is treated with hydrochloric acid, filtered, the filtrate shaken with ether, decanted, the ether evaporated, and the reagent added to the residue.

Test for tyrotoxicon.—Render the milk alkaline with sodium carbonate, shake with ether, which separates out the poison, allow the ether to evaporate, dissolve the residue in water, filter, and evaporate the filtrate.. A mixture of equal parts of pure carbolic and sulphuric acids gives an orange-red or purple colour if even traces of tyrotoxicon be present. Chemically tyrotoxicon is very unstable, and milk which contains it in considerable amount may in a short time be entirely free from it.

The accidental impurities of milk would be greatly lessened if strict cleanliness of milch cows, the milker's hands, cow-sheds, and milk-pails were enforced, and if the operation of milking were conducted in the open air.

Proper storage, hygienic construction, and cleanliness of milk shops are likewise essential.

Ice-Cream.—The examination of ice-cream is essentially the same as that of milk. It is often kept under most unsuitable conditions, such as in the neighbourhood of dirty water-closets, and may absorb organic vapours or contain virulent toxines or pathogenetic bacteria.

Butter.—*Colour.*—The colour varies according as the butter is fresh or salt, and may be heightened by the addition of vegetable colouring agents, such as annatto and carotin.

Smell.—This may be rancid if the butter be decomposed.

Taste.—This may be altered in various ways. Butter which has been in contact with the wood of the cask or keg is often disagreeable to the palate, though not necessarily bad.

These physical properties scarcely serve to distinguish butter from its imitations.

Chemical Examination.—*Water* is estimated by evaporating a given quantity of the butter in a tared vessel, first over a steam bath, then in a hot chamber. Cool and weigh. The loss in weight is expressed as a percentage, and should not exceed 12 per cent.

Ash.—This is obtained by incinerating a given quantity of butter in a tared vessel, cooling and weighing. The ash is expressed as a percentage, and may range from 2 to 7 per cent. This is almost entirely common salt, which may also be estimated by (*a*) dissolving the ash in water and titrating with a standard solution of silver nitrate, or (*b*) washing the butter with hot distilled water and titrating in the same way.

Casein or curd is obtained by removing the fat with ether, washing out the salt, evaporating the water and weighing the curd, which should constitute about 2·5 per cent.

Fat.—Subtract the quantities of water, salt, and casein from 100, and the result gives the fat, which may also be directly determined by extracting it from dry butter with ether, distilling off the ether, cooling and weighing. It should be about 83 per cent. of the whole.

Analysis of Butter Fat.—The butter fat is obtained for this purpose by heating butter to 100° C. and decanting the top layer.

1. *Specific gravity.*—This is determined by a specific-gravity bottle, and should not be less than ·911.

2. *Melting point.*—Butter fat melts at a lower point than other fats which are substituted for it, the melting beginning about 19° C.

3. *Volatile fatty acids.*—If butter fat be saponified by the action of caustic potash in the presence of alcohol, the acids of which it is composed can be liberated from the soap by means of dilute mineral acid, and the volatile components distilled over into a decinormal solution of soda. By titration of this with oxalic acid the amount of volatile acids can be calculated. They are stated as butyric acid, and should constitute 5 to 6 per cent. of the butter fat.

4. *Fixed fatty acids.*—The butter fat is saponified as before, and the soap dissolved in distilled water and transferred to a tared capsule. The acids are

liberated by the addition of dilute mineral acid, and the capsule is alternately heated and cooled over a water bath. The soluble acids are washed out with distilled water, and the washing continued till the solvent has no acid reaction. The remaining insoluble acid is dried, weighed in the capsule, and expressed as a percentage of the butter fat, of which it should constitute not more than 88 per cent.

Microscopic Examination.—This is of importance in distinguishing butter from margarine, both of which are best examined in 1 per cent. osmic acid. The fat globules of the former are much of a size, those of the latter more variable, and some much larger than any possessed by butter.

Bacteriological Examination may be made for pathogenetic microbes, such as those of typhoid and tubercle. It is stated that these retain their vitality for a longer period in butter than in milk. In making butter, most of the bacilli present in the milk are expressed in the whey.

Adulterations and their Detection.—Water may be beaten into the butter in order to increase its weight. It is detected in the chemical test. A deficiency of water is sometimes associated with the presence of adulterant fat. The most common falsification is the addition of animal and vegetable fats in place of the milk fat. The fat of the ox, sheep, horse, or pig, palm, rape-seed, cotton-seed, or cocoa-nut oils may be substituted. Chemical examination of the fat betrays the fraud, the specific gravity being below ·906, the melting point high, the volatile fatty acids greatly reduced, and the fixed fatty acids over 88 per cent. Another test is the Valenta test, which consists in heating a mixture of equal parts of the butter fat and glacial acetic acid to 100° C., allowing it to cool, and noting the temperature at which opacity is first visible. If the butter is adulterated, this occurs at 96·5° C.; if pure, not till 61·5° C. Jean's modification of this test depends upon the absorption of glacial acetic acid by the fat, butter fat absorbing about 60 per cent., and other animal fat and the vegetable fats less than 30 per cent.

Starch, whether in the form of potato starch or otherwise, is sometimes present, and is to be detected by its colour reaction with iodine. Annatto and carotin, especially the former, are in common use as colouring matters, while saffron is not unknown. A less innocent pigment is the yellow chromate of lead.

Boracic acid or borax is frequently added as a preservative; it is tested for in the same way as in milk (p. 237).

Margarine.—The tests are the same as for butter. It contains from 8 to 14 per cent. of water, slightly more ash than has butter, and some 83 per cent. of fat. Margarine fat has less than ·5 per cent. of volatile fatty acids, and usually over 95 per cent. of fixed fatty acids.

Cheese.—Tyrotoxicon may be present in cheese, and is detected by its colour test (p. 237). Metallic poisons, such as arsenic and copper, are detected respectively by Reinsch's or Marsh's tests, and by ammonia or potassium ferrocyanide. Lead may be also present in the rind, being derived from the tinfoil in which cheeses are sometimes wrapped. Moulds are recognised by the microscope, and may give a blue, green, or red colour to the cheese. Maggots are occasionally found. Admixture with such substances as starch is the only fraud commonly in vogue. Ptomaines are chiefly present in cheeses which have an acid reaction. Oleomargarine may be used instead of milk in the manufacture of cheeses.

Wheat.—The wheat grain must be examined microscopically for the parasitic diseases already mentioned. Klein and Houston have recently demonstrated the occasional presence of *B. enteritidis sporogenes*, *B. coli communis*, and *B. citrus cerealis* on the grain of wheat and other cereals. The starch grains must be recognised. They vary much in size and shape, and rarely show concentric markings or hilum. Those of intermediate size are conspicuous by their absence (Fig. 73, *a*).

Flour.—Physical Tests.—Flour should be a smooth, soft, white, homogeneous powder without acid taste or mouldy smell. If a handful be thrown against a board, some of it should stick, and dough made from it should be coherent. Old flour is yellow, acid, or sour, and full of rough particles.

Chemical Examination.—Good flour is neutral or faintly acid in reaction.

Water is estimated by evaporation and weighing. Average = 14 per cent. It should not be above 18 per cent.

Ash is obtained in the usual way. There should not be more than 1 per cent., nor less than ·5 per cent.

Glutin is got by forming a dough and freeing it of starch by repeated washing. It is then weighed as wet or dry glutin. The former should constitute about 25 per cent. of the flour, and is 2·3 times as heavy as the same glutin after drying. Dry glutin varies from 8 to 12 per cent.

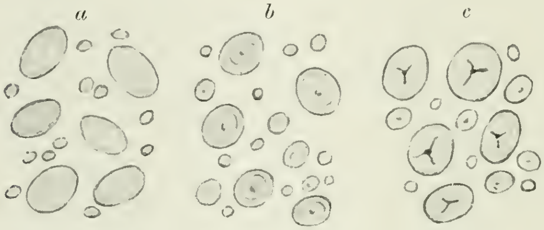


Fig. 73.—*a*, Wheat. *b*, Barley. *c*, Rye. × 200 diameters.

Total albumin is determined from the amount of nitrogen yielded by Kjeldahl's method (p. 174), multiplying the result by 6·25, there being one part of nitrogen in 6·25 parts of albumin. It is expressed as a percentage, and constitutes about 15 per cent. of the flour.

Starch is first of all converted into sugar by the addition of water and dilute mineral acid and the application of heat. It is then estimated by titration with Fehling's solution, of which 10 c.c. is equivalent to ·05 grms. of glucose. Having ascertained the percentage of glucose, nine-tenths of this gives the percentage of starch. The average quantity is about 70 per cent.

Fat.—There is only about 1 per cent. of fat, and this can be extracted with ether.

Adulterations and their Detection.—Adulteration with barley, oats, rye, maize, rice, buckwheat, millet, linseed, potatoes, peas, and beans is to be detected by examination of the starch grains microscopically. Various mineral adulterations may be present, of which the chief is alum, which add to the quantity of ash. They are rarely present, and may be demonstrated by separating out the other constituents of the flour with chloroform and testing the sediment. Darnel seeds are detected by the addition of alcohol. A green solution is obtained which possesses a disagreeable taste.

Tests for ergot.—Warm a sample of the flour with solution of caustic potash, when, if ergot be present, the herring-like smell of propylamine will be apparent. Ergot gives a red colour when some of the flour containing it is shaken up with alcohol and a trace of hydrochloric acid. A similar colour may be obtained if the flour is mixed with ether and a little oxalic acid, boiled and allowed to settle. Anilin violet stains starch grains affected by ergot much more easily than those of normal flour. Ergot is also detected microscopically by the appearance of its cells (Fig. 70).

Bread.—The crust of bread should weigh almost one-third of the loaf, the cavities of the crumb should be equally distributed and much of a size, and the crumb should not be tough. The colour of a loaf will depend on the amount of bran in the flour, and bread should possess neither an acid taste nor a sour smell.

Chemical Examination.—*Water.*—The amount varies respectively in the crust and crumb, being much higher in the latter. It must be estimated in both, and the total stated as a percentage of the whole loaf. The bread must be powdered before it is weighed and heated. The average percentage of water is 38.

Acidity.—The acids are acetic and lactic acids, and the acidity is calculated in terms of the former. The bread is soaked in hot distilled water, filtered, and the filtrate titrated with decinormal alkali. This acidity is stated as a percentage of the whole loaf, and can be calculated separately on the crust and crumb. It should not exceed 1 per cent.

Ash is estimated after the water has been determined, and should be about 1 per cent.; silicate of alumina may be one of its constituents.

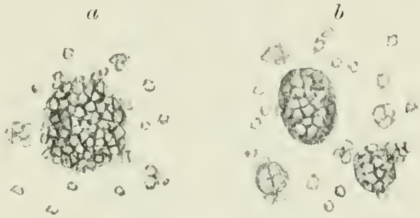


Fig. 74.—*a*, Rice starch. *b*, Oat starch. × 200 diameters.

Adulterations and their Detection.—The chief adulterations are alum, potatoes, copper sulphate, and lime. Alum is added to inferior flour to improve its coherency when made into dough, and also to give the bread a good white colour. It may be detected by soaking a piece of the bread in a mixture of equal parts of a 5 per cent. solution of logwood in alcohol and a solution of carbonate of ammonia. If alum is present, the bread on drying becomes blue instead of brown. Alum may also be determined in the ash by a lengthy and complicated process. If the bread be acid and the ash alkaline, the presence of the salts of organic acids, which become carbonates on incineration, can be inferred; this points to adulteration with potato. An alkaline bread with a similar ash contains sodium carbonate. The presence of copper is shown by the brick-red streak which appears when a glass rod, dipped in potassium ferrocyanide, is drawn across the surface of a piece of the bread.

With regard to the other cereals, the important thing is to discriminate between their various starch grains.

Oats.—The starch grains are small, polygonal, coherent, have no hila, and form rounded masses. They do not polarise light (Fig. 74, *b*).

Barley.—The starch grains are very like those of wheat, but a hilum and some indication of concentric markings are usually visible. Intermediate sizes are more frequently found (Fig. 73, *b*).

Rye.—The granule is very typical, being large and showing a star-like hilum (Fig. 73, *c*).

Maize shows starch grains of moderate size, which have each a distinct hilum and facetted sides (Fig. 75, *c*).

Rice granules are very small, angular, and form irregular masses. A hilum is rarely seen (Fig. 74, *a*).

Fig. 75.—*a*, Pea starch. *b*, Bean starch. *c*, Maize starch. × 200 diameters.

The other vegetables whose starch grains require recognition are—

Peas and Beans.—The granules are oval or kidney-shaped, and each has a long hilum, more branched in peas than in beans (Fig. 75, *a* and *b*).

Potatoes have large granules resembling mussel-shells in their concentric ringing, and having a hilum corresponding in position to the umbel of the mussel-shell (Fig. 76, *a*).

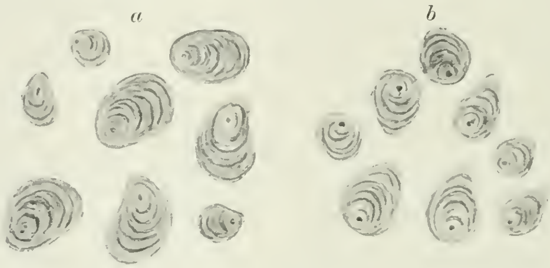


Fig. 76.—*a*, Potato starch. *b*, Arrowroot starch. × 200 diameters.

Arrowroot granules are very like those of potatoes, but the hilum is at the broad end of the grain as a rule, though this depends on the variety of the starch (Fig. 76, *b*).

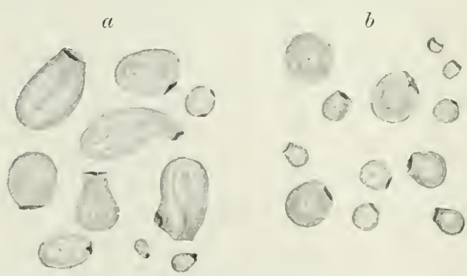


Fig. 77.—*a*, Sago starch. *b*, Tapioca starch. × 200 diameters.

Sago grains are large and irregular, often truncated at the end where the hilum is placed. The rings are ill-defined (Fig. 77, *a*).

Tapioca granules are like those of sago, but much smaller (Fig. 77, *b*).

Sugar.—The presence of saccharin in sugar is shown by drying and extracting with anhydrous ether, in which sugar and glycerine are insoluble. Hence, if the residue, after evaporation, has a sweet taste, saccharin has been added.

Fruits.—As regards fruits, it is worthy of note that biebrich scarlet, an anilin dye-stuff, is sometimes injected into oranges to make them simulate blood oranges, which command a higher price in the market.

TABLE OF AVERAGE PERCENTAGE COMPOSITION OF CERTAIN FOOD-STUFFS.

	Proteid.	Carbohydrate and Cellulose, if any.	Fat.	Total Solids.	Ash.	Water.
Milk . . .	3·50	4·50	3·30	12·00	0·70	88·00
Butter . . .	1·00	1·00	83·00	88·00	3·00	12·00
Cheddar cheese .	28·00	...	33·00	...	4·00	35·00
Wheat flour . .	14·00	70·00	1·00	...	0·70	14·30
Oatmeal . . .	15·00	67·00	8·00	...	2·00	8·00

BEVERAGES.

Liquids used as beverages may be divided into four main classes—(1) Aqueous; (2) alcoholic; (3) alkaloidal; (4) antiscorbutic.

I. AQUEOUS.

Water, while forming the basis of all beverages, is itself the best of beverages. It may be aerated or contain mineral salts. The aeration of water with carbonic acid gas, though it aids digestion both chemically and mechanically, does not prevent it being a carrier of active pathogenetic microbes, except perhaps in the case of the cholera vibrio. Most of the so-called mineral waters are manufactured from artesian well water, in which the chances of bacterial contamination are slight.

II. ALCOHOLIC.

It has been calculated that from 1 to 1½ fluid oz. of pure alcohol can be absorbed and utilised by a healthy adult human body without traces of its presence being apparent in the urine. Apart from idiosyncrasy, this quantity may be regarded as the limit of its daily use as a beverage. It is not an essential article of diet, and has been proved to be distinctly injurious to the young. To persons engaged in hard bodily and mental work, or exposed to extremes of climate, alcohol is pernicious, unless taken in strict moderation. It is a true food, is absorbed unaltered from the stomach, and spares fats and carbohydrates, but does not lessen nitrogenous waste. Its heat value is 7 Calories per grm., and it is not so good a source of heat and energy as is fat. In small doses it aids digestion, in large doses inhibits it. The general influence of alcohol is bad, owing to the fact that, instead of being a useful servant, it too often becomes a tyrannical master. The experience of life assurance offices is in favour of total abstainers, but there are no data available by which to compare this class with those temperate consumers of alcohol who never exceed 1 oz. per day. In the forms in which it is usually taken, alcohol is not inimical to pathogenetic micro-organisms, while the proportion of spirituous liquors taken in water is quite inefficient to destroy any such microbes which may be present in the water. Fourteen per cent. of rectified spirit in nutrient jelly does not inhibit the plentiful growth of such an organism as the *B. coli communis*. In the intestine, however, such a proportion would seriously interfere with the pancreatic digestion.

SPIRITS.—*Whisky* is made from malted barley alone, or a malted mixture of barley, rye, and maize. Oats and potatoes may also be used. By malting is meant the conversion of the starch grain into sugar by the action of the ferment diastase. Further fermentation of the sugar results in the production of alcohol, which is then distilled. Whisky contains rather less than 50 per cent. of alcohol by volume. Freshly-prepared and even old whisky contains fusel oil, a mixture of propylic, amylic, and butylic alcohols, which was supposed to be powerfully toxic to the nervous system. This, however, is open to question, as the result of recent experiments. It is possible that some other bye-product is responsible for the ill effects produced by immature whisky, and so long attributed to fusel oil.

Brandy is the product of the distillation of fermented grape juice. It contains from 50 to 60 per cent. of alcohol, and various volatile and aromatic ethers, which increase with the age of the brandy. Cheap brandy consists of coloured alcohol, not derived from grapes at all, and is deficient in these valuable volatile ethers.

Gin is got by fermenting a mixture of rye and malt, or malt and barley, and repeatedly distilling. Juniper, and sometimes oil of turpentine, hops, and other substances, are added. It contains from 40 to 50 per cent. of alcohol.

Rum results from the distillation of molasses, and contains from 50 to 60 per cent. of alcohol. It is coloured with burnt sugar, and its taste is due to ethyl butyrate.

Liqueurs contain much alcohol, even up to 60 per cent., and much sugar is also present.

Absolute alcohol is never used as a beverage. It contains no water, and has a specific gravity of ·793. Rectified spirit has 84 per cent. of absolute alcohol. Proof spirit is the standard spirit used for excise purposes, and contains 57·05 per cent. of absolute alcohol by volume, the remainder being distilled water. There is 1 part of alcohol in 1·753 parts of proof spirit. A spirit which is said to be 10 degrees above proof is one which contains in 100 volumes as much alcohol as 110 volumes of proof spirit.

Conversely, a spirit 10 degrees under proof has as much alcohol in 100 volumes as is present in 90 of proof spirit. To compare a spirit, such as whisky, with proof spirit, multiply the percentage volume of alcohol in the whisky by 1·753, and inasmuch as the product differs from 100, so much will the whisky be under or over proof.

Example.—A whisky containing 45 per cent. of alcohol is 21·115 degrees under proof, because $100 - (45 \times 1{\cdot}753) = 21{\cdot}115$. If the percentage of alcohol were 60, the liquor would be 5·18 degrees above proof $(60 \times 1{\cdot}753) - 100 = 5{\cdot}18$. Obviously, if the strength under or over proof be known, the percentage of alcohol by volume can equally be calculated.

$$\text{Thus } \frac{100 - 21{\cdot}115}{1{\cdot}753} = 45, \text{ and } \frac{100 + 5{\cdot}18}{1{\cdot}753} = 60.$$

The law permits whisky, brandy, and rum to be sold 25 degrees, and gin 35 degrees, under proof.

The percentage by volume of alcohol in any spirit is to its percentage by weight in volume as 5 to 4.

Besides alcohol and water, spirits contain a very small percentage of solid matter, and almost no sugar. Their acidity is low, that of brandy being the highest.

Examination of Spirits.—The proportion of alcohol in spirit may be determined by means of a hydrometer or a specific-gravity bottle, which give the specific gravity, and a reference to tables shows the percentage of alcohol corresponding to this specific gravity.

Another method is like that in vogue for beer (p. 246). Acidity is determined by decinormal alkali solution ; fixed acids, as in brandy, being expressed as tartaric acid, volatile acids in other spirits as acetic acid. Each c.c. of decinormal solution is equivalent to 7·5 mgrms. tartaric acid and 6 mgrms. acetic acid.

Adulterations.—The chief fraud is the addition of inferior spirit, but sulphuric acid may be added to brandy and gin after distillation, and in such an event arsenic might possibly be present. Crude sulphuric acid may be added during the distillation of whisky to get rid of certain hydrocarbons in the still.

Beer is the product of the yeast fermentation of malt, to which hops have been added. Malt is obtained by the germination of barley, the starch of the grain being changed to malt sugar. Other substances than malt are used in beer manufacture, and other bitters besides hops are employed to give it its characteristic taste. Among these substitutes for malt sugar are glucose, invert sugar, and cereal starches ; and the other bitters include any that are wholesome, such as quassia, gentian, etc.

Variations in the yeast and in the quantity of hops used, and in the temperature and rate at which fermentation is conducted, determine the character of the beer, whether light German (bottom yeast) or heavy English (top yeast). Hard water is generally used in brewing the latter, and soft water in brewing the former.

The souring of beer is due to the conversion of alcohol into aldehyde, and then into acetic acid.

Stout or Porter is also produced from malt, and owes its colour to caramel, produced by a process of roasting to which the malt is subjected. Stout differs from beer in being more acid and containing more solid matter. Owing to the fact that beer contains carbohydrate, a small percentage of proteid, and some mineral matter and vegetable acids, it is to be regarded as a food as well as a beverage ; but although its Calorie value is practically the same as that of milk, it is by no means equally valuable as a source of energy. If taken in excess, beer is deleterious, leading to retention of effete products and the accumulation of a superfluity of fat.

Composition.—Beers vary considerably in their composition, of which a percentage average representing no special beer may be taken as proteid ·5, carbohydrate 10, salts ·2, carbonic acid ·15, alcohol 5, water 84·15.

The specific gravity of beers lies between 1006 and 1030.

Examination of Beer.—*Specific gravity.*—This is determined by a hydrometer, and must be taken at 15° C.

Total acidity.—This is determined by titrating with decinormal alkali solution, and stating the result as a percentage in terms of lactic acid, each c.c.

of decinormal solution being equivalent to 9 mgrms. lactic acid. The total acidity includes that due to fixed acids, lactic, etc., and that dependent on volatile acids, acetic, carbonic, etc. The fixed acidity may be obtained by distilling the beer, driving off the volatile acids, and titrating the residue as for total acidity. The difference between the amounts of decinormal alkali used for fixed and total acidity gives the means of determining the volatile acid, which is then stated in terms of acetic acid.

The total acidity should be about ·16 per cent.

Alcohol.—The percentage of alcohol may be got from (1) the specific gravity of the beer; (2) the specific gravity of the alcohol obtained from it on distillation; and (3) the specific gravity of the residue after distillation of the alcohol, and making up with distilled water to the original quantity of beer. Thus, if the specific gravity of the beer be 1007, of its alcohol 993, and of the made-up residue 1014, the percentage of alcohol is found from a table as 5 per cent. The accuracy of the result is confirmed by deducting 1007 from 1014, and their difference 7 being deducted from 1000 gives 993.

Total solids are determined by evaporating in a tared vessel and weighing. They are from 3 to 10 per cent. of the beer, and consist chiefly of the malt extract.

Ash is got by incineration of the total solids and re-weighing. It is composed of alkaline chlorides and phosphates.

Sugar is estimated on the made-up residue after distillation of the alcohol. This is decolorised by animal charcoal, filtered, and the filtrate titrated with Fehling's solution, of which 10 c.c. = ·05 grms. maltose. The sugar amounts to less than 1 per cent. of the beer.

Adulterations and their Detection.—*Water* forms the chief adulterant added to beer, and may be detected by the low percentage of alcohol and the low specific gravity of the residue of the beer after distillation of the alcohol.

Salt is added to increase the thirst of the consumer, and may be estimated by dissolving the ash in distilled water and titrating with a standard solution of silver nitrate.

Sulphate of lime is usually derived from the hard water used for brewing, and is more rarely added as an adulterant. The lime may be estimated by dissolving the ash in dilute acetic acid and precipitating with ammonium oxalate and weighing.

Alum, salt, and sulphate of iron together are added to give a "head" to flat beer. The alum is detected in the ash as in that of bread. The iron salt is determined in the beer by the Prussian blue test; but if the beer be dark coloured, it must first be decolorised.

Effervescing powders may also be used to overcome the flatness of beer. *Sodium bicarbonate* or *chalk* may be added to lessen the acidity of beer. A high fixed acidity suggests the addition of *sulphuric acid*, which may have been added to clarify and flavour the beer. *Liquorice* or *sugar* may be added to beer to increase its body and improve its colour. *Poisonous bitters*, of which the most important is *picrotoxin*, are now but rarely found in beer. The recent serious outbreak of peripheral neuritis in Manchester has drawn attention to the fact that beer may contain *arsenic* derived from (1) glucose prepared with crude sulphuric acid obtained from iron pyrites containing arsenic; (2) malt in the manufacture of which gas coke has been employed; (3) hops which have been sprayed or bleached with sulphur containing arsenic. The quantity of arsenic present in the Manchester beer was found to be from 1 to 3 grs. per gallon. It is suggested that beer containing ·08 grs. of arsenious acid per gallon should be condemned, and that the best test for arsenic in beer, glucose, or hops is Reinsch's test. Marsh's test is not applicable to beer unless any organic matter in the beer be previously broken up. In applying Reinsch's test to beer, the copper foil is boiled in the beer; it is then removed and placed in a copper cone, whose base is covered by a cover-glass. The apex is heated, arsenic volatilises and sublimates in typical crystals on the cover-glass (Delépine).

Preservatives, especially salicylic acid and sodium fluoride, may be added to beer. The former may be detected by the blood-red colour which forms on addition of a few drops of a 10 per cent. solution of potassium nitrite, an equal quantity of acetic acid, and one drop of a 10 per cent. solution of copper sulphate.

Wine, according to Professor Blackie, "the proper drink for man," is a beverage derived from the grape by fermentation, white wines being prepared from the juice, and red wines from the whole grape.

Composition.—This varies much, according to the process of preparation; and wine contains alcohols, ethers, sugar, extractive matter, fat, fixed and volatile acids, salts, and glycerine.

Alcohols.—The chief is ethyl alcohol, which in pure or unfortified wines does not exceed 15 per cent. When this proportion is reached, the fermentation of sugar ceases. Fortification of wine consists in the addition of alcohol, and has for its object not only an increase in alcoholic strength, but the prevention of acetous fermentation, and consequently the preservation of the wine.

Ethers.—These form only a small proportion of the wine, but impart to it its bouquet and some of its valuable medicinal effects.

Sugar.—This is chiefly lævulose or fruit sugar, though some dextrose is also present. The quantity varies very much, according as the wine is sweet or dry.

Extractive matter.—There is little albumin, some carbohydrate, such as pectin and gums, and colouring matter. The last is derived from the grape skin.

Fat.—A trace of fat from the skin and kernels of the fruit is to be found in some wines.

Acids.—*Fixed.*—These are chiefly tartaric, malic, and tannic, and may exist as salts in combination with potassium. *Volatile.*—The most important is acetic, produced in the process of fermentation by the *Mycoderma aceti*, from the alcohol, or later, by the oxidation of alcohol, which, in virtue of the albuminous substances it contains, wine undergoes on exposure to air.

Salts.—These are tartrates, sulphates, phosphates, and chlorides of such bases as potassium, sodium, calcium, and magnesium.

Glycerine is always present, and is a product of fermentation.

Wine, unlike beer, is not a food, but resembles it in stimulating the gastric secretion and retarding salivary digestion, owing to the acid it contains.

Examination of Wine.—This includes the estimation of the specific gravity, alcohol, total solids, ash, sugar, and acidity.

The specific gravity is taken as in beer, and varies, ordinary claret being about ·998.

Alcohol.—Estimate as in beer.

Total solids and ash are determined as in beer, in claret the former being about 2·3, and the latter about ·2 per cent.

Sugar.—This is estimated by means of Fehling's solution after alkalinisation and decolorisation of the wine. Dry wines are best decolorised by animal charcoal, and sweet wines by basic lead acetate. The sugar is calculated as glucose, and 10 c.c. Fehling's solution = ·05 grm. glucose. In claret we have found it ·075 per cent.

Acidity is obtained as in beer. The fixed acidity is returned as tartaric acid, each c.c. of decinormal solution being equivalent to 7·5 mgrms. tartaric acid. If necessary, the wine may be decolorised before the test is applied. The average is about ·5 per cent. The volatile acidity is calculated as acetic acid, each c.c. of decinormal solution being equivalent to 6 mgrms. of acetic acid: ·1 per cent. may be taken as an average.

Adulterations and their Detection.—*Water.*—Its presence as an adulterant is recognised as in beer.

Alcohol.—If the amount of alcohol varies much from the normal percentage found in the kind of wine under examination, sophistication is indicated.

Artificial colouring matter, with the exception of rhatany, is to be detected by the immersion in the wine of small gelatine cubes. If these become coloured throughout within forty-eight hours, the wine is not pure.

Lime in the form of sulphate is used in the manufacture of certain wines, especially sherries, the process being known as "plastering." If, however, the amount of lime exceed ·03 per cent., it is probable that an excessive quantity of lime has been used. It is determined by evaporation to dryness, dissolving the residue, precipitating with oxalate of ammonium solution, filtering, incinerating, and weighing.

Tannin may be present, and is indicated qualitatively by the dark colour produced on the addition of perchloride of iron.

Alum is detected in the ash as in bread.

Lead and copper are detected in wine as in water.

Arsenic may occur in wines owing to the use of artificial manures, the spraying of the vines with sulphur containing the metal, the plastering of wines with various sulphates, or the employment of anilin dyes as colouring agents. It is to be tested for as in beer.

III. ALKALOIDAL.

These are beverages whose active principles are alkaloids, and the group includes tea, coffee, cocoa and chocolate, Paraguay tea, guarana, kola and coca.

Tea as a beverage is an infusion made from the dried leaves of *Camellia thea.* The younger leaves yield the best tea. Tea is termed green or black according to the treatment the leaves undergo. In the latter variety they are permitted to ferment, this being the essential difference in the treatment, which otherwise consists of drying, rolling, etc. Chemically, green and black tea differ greatly in the amount of tannic acid they contain, the green tea containing much more than the black.

Composition.—The leaves contain water, thein (*syn.* caffein), tannic acid, dextrin, glucose, and extractives, insoluble organic matter (albumin, cellulose, chlorophyll, and resin), salts, and volatile oil. The method of preparation of the infusion largely determines the good or bad effects produced by tea. The water used should be well aerated, moderately hard, and just on the boiling point. The time of infusion should be short, and the same leaves should not be used twice.

Owing to its active principle and its volatile oil, tea is a nerve and heart stimulant, but, on account of the large amount of tannic acid it contains, its influence on peptic digestion is wholly detrimental, though this is somewhat lessened by the addition of milk or cream.

Examination of Tea.—The tea leaf may be examined by uncurling it in water, drying it between sheets of blotting-paper, and examining it with or without the aid of a magnifying-glass. It is elliptical in shape, with a serrated margin, notched at the top. There is a central midrib from which lateral veins spring, but these do not reach the margins of the leaf, but turn upwards and anastomose with each other (Fig. 78, *a*). If a ribbed portion of the leaf be soaked in strong alkaline solution, certain large branched cells, termed idioblasts, may be seen on examining a section microscopically. They are of diagnostic importance (Fig. 78, *b*).

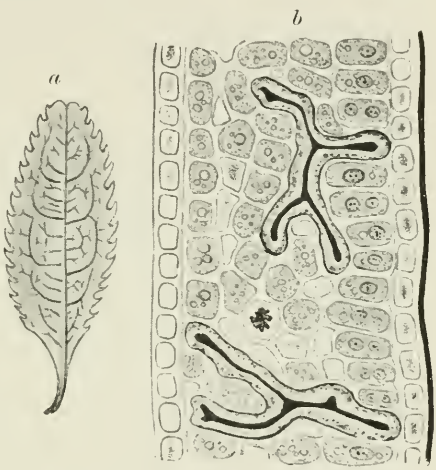


Fig. 78.—*a*, Tea leaf, × 2 diameters. *b*, Section of tea leaf showing idioblasts, × 160 diameters. (After Pakes.)

Water is estimated by evaporation and weighing. Average, 7 per cent.

Ash is obtained by incineration and weighing. Average, 6 per cent.

Extract is determined by mixing the leaves with distilled water and heating over a water bath, straining the product through muslin, and repeating the process till the washings are colourless. The filtrate is made up with distilled water to a definite quantity, and a portion of this evaporated in a tared capsule and weighed. The weight of the whole extract can be calculated from this, is expressed as a percentage of the tea, and is termed the *total soluble extract.* It contains tannic acid, thein, volatile oil, soluble albumin, dextrin, glucose, pectin, and the soluble salts. Average amount, 36 per cent.

Soluble ash.—If the total soluble extract be incinerated and weighed, the amount of soluble ash is forthcoming. Average, 3 per cent.

Thein or caffein.—This is calculated from the nitrogen contained in the soluble extract after subjection to the following process. Some of the soluble extract is diluted with distilled water, the albumin precipitated with copper sulphate and caustic potash, and the fluid filtered. A portion of the filtrate is used for Kjeldahl's process (p. 174), which is then employed. There is 1 part of nitrogen in 3·46 parts of thein, and the average amount of the latter in tea is 2 to 4 per cent.

Tannic acid.—Make an infusion and add solution of gelatine which precipitates the tannic acid. The sediment is collected, dried and weighed.

and 100 parts of it contain 40 parts of tannic acid. Tea contains 10 to 12 per cent. of tannic acid.

ADULTERATIONS AND THEIR DETECTION.—Other leaves, such as those of the sloe, the willow, and various other shrubs and trees, may be added to tea. The presence of the idioblastic cells already mentioned is the best means of distinguishing, as they are peculiar to tea leaves. Exhausted tea leaves, doctored with catechu and gum, may be added as an adulterant, and may be detected by their want of aroma, by the presence of catechu, and by the increase of total ash and diminution of soluble ash and soluble extract.

COFFEE is the kernel of the fruit of the *Caffea arabica*, and it is first roasted and then ground, in order that an infusion may be prepared from it. Unroasted and roasted coffee beans differ in their composition, the roasted bean containing less moisture and less caffein, but more aromatic oil and caramel. Good coffee can only be made from beans which have been recently ground.

COMPOSITION.—Coffee contains water, caffein, tannic acid, dextrin, and sugar, insoluble organic matter, fat, salts, and aromatic oil. Thein and caffein are the same alkaloid, and thus coffee has the same stimulating action on the heart and nerves as tea, but does not so powerfully interfere with salivary and peptic digestion.

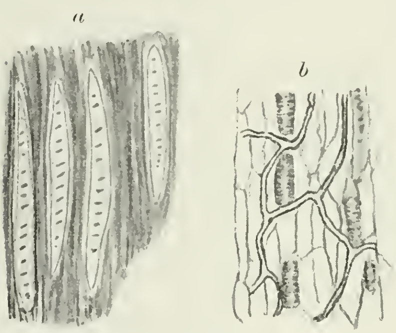


FIG. 79.—*a*, Coffee membrane. *b*, Chicory. × 80 diameters.

EXAMINATION OF COFFEE.—The coffee bean consists of two halves in apposition surrounded by a husk. Ground coffee examined microscopically in an alkaline solution, shows long spindle cells in its membrane (Fig. 79, *a*), whilst the interior contains thick polygonal cells and some fat globules. The moisture, ash, soluble extract, soluble ash, and caffein are all estimated as in tea, their average percentage quantities being respectively 2 to 3 per cent., 4 per cent., 25 per cent., 3 per cent., 2 to 4 per cent. In addition, the fat must be determined. It is extracted with ether and weighed. It amounts to from 12 to 13 per cent.

ADULTERATIONS AND THEIR DETECTION.—Chicory, the ground dried root of the wild endive, can hardly be considered an adulteration unless its presence is not declared by the vendor. Its addition is not illegal, and there is often 30 per cent. of it present in the mixture.

Coffee plus chicory has less caffein and less fat, but more sugar, and when thrown into water the coffee floats, while the chicory sinks, leaving a brown tell-tale track behind it.

Microscopically, chicory is recognised by its open parenchyma and its peculiar dotted ducts (Fig. 79, *b*). The amount of chicory may be found from the specific gravity of a 10 per cent. infusion of the mixture, since the specific gravity of a 10 per cent. infusion of pure coffee is 1010, and of a similar strength of pure chicory 1023. If the specific gravity of the infusion of the mixture be 1015, the percentage of coffee is 61·5, and of chicory 38·5.

Thus, if x be the percentage of coffee—

$$x \times 1010 + (100 - x) \times 1023 = 100 \times 1015, \text{ and } x = 61{\cdot}5,\ 100 - x = 38{\cdot}5.$$

A similar calculation may be made from the amount of soluble extract, which in coffee is 25 per cent., and chicory 70 per cent. If coffee be adulterated with starch, this may be detected by the microscope or by testing with iodine. Caramel or burnt sugar is sometimes added.

Cocoa is the seed of the fruit of the *Cacao theobroma.* Cocoa nibs are the halves of the seed separated by roasting and pressure. The various forms of cocoa are prepared from these by grinding, heat, and pressure for the removal of cellulose and fat.

Composition.—The cocoa bean contains water, theobromine, tannic acid, fat, albuminous matter, starch, salts, cellulose, and gum. If its constituents alone be considered, cocoa is a valuable food, but so little of it can be taken at a time that it is practically reduced to the level of a mere beverage. Cocoa does not possess the same stimulating properties as tea and coffee, for though theobromine is closely allied to caffein, so little of it is taken that its action is not marked. About half the weight of the cocoa bean is fat, but the commercial article is much depleted in this respect, and rarely contains more than 30 per cent.

Examination of Cocoa.—To satisfactorily examine cocoa nibs under the microscope, they must be treated with ether to remove the fat, or the latter must be saponified with caustic soda. The husk shows cellular hairs, and the substance of the bean exhibits small cells, amongst which are embedded the starch granules. These are like those of rice as regards size, but are round instead of angular. The constituents of cocoa are to be estimated in the same way as those of the other alkaloidal beverages. The proportion of nitrogen in theobromine is 1 in 3·214 parts.

Averages.—Moisture 7 per cent., ash 5 per cent., fat 15 to 33 per cent., theobromine 1 to 2 per cent., tannic acid 5 per cent., albuminous matter 10 per cent., cellulose 10 per cent., carbohydrate 25 per cent. The various commercial cocoas all differ, especially in the amount of fat and carbohydrate they contain.

Adulterations and their Detection.—In the preparation of the cocoa powder, alkalies, starch, and sugar may all be added to cocoa. If this is done in moderation, these can scarcely be regarded as adulterants, since their object is to render cocoa less oleaginous and hence more digestible. Unfortunately these ingredients are often in excess, and too much of the fat may be removed. Excess of alkali may be detected in the ash, foreign starch is found microscopically, and Fehling's test reveals the sugar. Sand or other mineral substances may be detected in the ash.

Chocolate is ground cocoa, which in the form of a confection has a portion of its fat removed, while as a beverage it contains more of the original cocoa fat. White sugar, starch, and flavourings are added. Chocolate provides nutriment in small compass, and in conjunction with a nitrogenous food-stuff, such as cheese, represents a large amount of sustenance in very small bulk.

Paraguay Tea and Guarana may be used instead of tea and coffee, and their chemical constitution is somewhat similar to that of those beverages; but guarana is specially rich in caffein.

Coca and Kola, the active principles of which are respectively cocaine and caffein, have gained a reputation as enabling one to undergo extremely hard exercise without ill effect and on very little food. This, however, is only the case when they are taken fresh, as in Africa and South America.

IV. ANTISCORBUTICS.

Lemon and Lime Juice.—The former is derived from the *Citrus limonum*, the latter from the *Citrus limetta*. Both contain free vegetable acids, chiefly citric acid, but the lemon is slightly more rich in this particular than the lime. Lemon juice, according to the British Pharmacopœia, should have a specific gravity of 1039, and should contain 32·5 grs. of citric acid per ounce. Alcohol is added as a preservative, and the Board of Trade standard enjoins a specific gravity of 1030 after dealcoholisation, and an acidity equivalent to 30 grs. of citric acid per ounce.

Lime juice has a specific gravity of 1035, and contains about 32·22 grs. of citric acid to the ounce. As used on shipboard, lemon or lime juice contains about 10 per cent. of spirit, and is covered with a layer of olive oil. As it is very sour, sugar is added to the ration in the proportion of half its weight. Boiling is a better means of preservation than the addition of alcohol. As already pointed out, these juices are our most valuable antiscorbutics, and at all times form a beverage conducive to health.

Examination.—Bad juice is recognised as being turbid, stringy, slimy, and having a precipitate, while its taste is often bitter. On boiling with hydrated calcium oxide (lime water), free citric acid yields a large precipitate of calcium citrate, which passes into solution on cooling. The specific gravity of the juice must be taken at 15° C., both before and after dealcoholisation.

Total acidity.—This is determined in the usual way by titration with a decinormal alkaline solution. It is expressed in terms of citric acid ($C_6H_8O_7$) either as a percentage or as grains per ounce, each c.c. of decinormal solution being equivalent to 6·4 mgrms. of citric acid.

Adulterations and their Detection.—These are water, various mineral acids, of which sulphuric acid is the most important, and tartaric acid.

Sulphuric acid is estimated in the diluted juice by precipitation with barium chloride, any barium citrate formed being dissolved by a few drops of hydrochloric acid. Boil, allow to settle, filter and weigh after incineration, a drop of dilute acid being added to the ash. The water used for dilution must be free from sulphates.

Hydrochloric acid is detected by a few drops of silver nitrate and a few drops of dilute nitric acid.

Tartaric acid may be thus discovered. Dilute the juice, and, if it be turbid, filter. Add a few drops of solution of acetate of potash, stir, and allow the potassium tartrate to settle as a precipitate.

Spurious lemon juice is made by dissolving crystallised citric acid in water (about 20 grs. to the ounce), and adding flavouring matter. This substitution may be detected by evaporation.

Vinegar is really acetic acid derived from various sources, *e.g.* malt, wine, cider, starch, molasses, sugar, and wood. Acetic acid, except when derived from wood, is the result of the oxidation of alcohol due to the *Mycoderma aceti*. The best vinegar is that made from weak wines. Vinegar contains, besides acetic acid, alcohol, ethers, sugar, alkaline acetates, and salts, and usually some sulphuric acid, which is limited by law to ·1 per cent. Vinegar, especially that made from wine and containing no sulphuric acid, is a valuable antiscorbutic, and if well diluted is a good and pleasant drink. It aids digestion by its power of softening cellulose and tough meat fibre.

Examination.—*Specific gravity.*—White wine vinegar varies from 1015 to 1022, and malt vinegar from 1016 to 1019.

Acidity.—Since acetic acid is volatile, the acidity of brown vinegar is determined by repeated distillation and titration of the distillate with decinormal alkali solution. Each c.c. of decinormal acid solution is equivalent to 6 mgrms. of glacial acetic acid. The acidity is expressed as a percentage, and averages 4 to 5 per cent. White vinegar may be titrated without distillation; the acidity thus obtained represents total acidity.

Adulterations and their Detection.—If water has been added, the specific gravity will be found below 1015, and the acidity below 3 per cent. Sulphuric acid in excess is indicated by a low specific gravity and a high acidity, and may be estimated by the same method as described under lime juice. A rapid test for free acid consists in bringing into contact on a porcelain slab, by means of a glass rod, a drop of the vinegar and a watery solution of methyl violet. Observe the change of colour. Acetic acid gives no change. A trace of mineral acid gives a blue colour, and over ·1 per cent. of mineral acid gives a green colour.

Salt may be present, and for its detection silver nitrate and dilute nitric acid are used.

Pyroligneous acid.—The residue after repeated distillation will possess the odour of this acid if it be present. Capsicum, pungents, and burnt sugar may be present, or various poisonous metals such as mercury, tin, lead, copper, or arsenic, to which vinegar has acted as a solvent. Bad vinegar often swarms with tiny vinegar eels, a species of worm.

CONDIMENTS.

A condiment is a substance taken along with the food for the purpose of stimulating the appetite and promoting digestion. Salt, mustard, and pepper are those most commonly in use.

Salt.—Pure salt is a dry, white, fine crystalline powder completely soluble in water. If impure, it is coloured, deliquescent, and crystallised in large masses. An ordinary mixed diet contains as much salt as is required for the needs of the body without its additional use as a condiment, about 2 grms. daily being all that is required. Vegetarians and herbivorous animals appear to require more salt than mixed feeders and carnivores, perhaps owing to the large quantity of potassium in vegetable food. Cerebos salt contains salt and a small quantity of phosphates. The adulterations of salt are corn starch, chloride of magnesium, and lime salts.

Mustard.—There are two kinds of mustard, black and white, the seeds of *Sinapis nigra* and *S. alba*, the latter being the larger. The seeds contain a ferment, myrosin, and a crystalline substance, which when moistened unite to form a volatile oil of allyl sulphocyanide. There is also a proportion of carbohydrate.

Examination of Mustard Seed.—Black seeds contain four, and white seeds five layers of cells and reticulum, and adulterations, such as wheat and rice, can be detected with a microscope.

Pepper.—There are likewise black and white peppers, the former derived from the unripe berries of the *Piper nigrum*, the latter from the same berries when ripe and decorticated. The seeds contain a pungent essential oil, an alkaloid, piperine, and a large quantity of carbohydrate.

Examination of Pepper.—Microscopically, the husk of the pepper seeds is seen to consist of several layers of cortical cells and woody fibre, enclosing a central portion with large angular cells nearly twice as long as their breadth. In water some of these cells assume a yellow colour, intensified by alcohol and nitric acid. The white part of the seed is composed of cells containing very small starch grains, which stain with iodine.

Adulterations.—Linseed, mustard husks, ground rice, rape cake, and flours may be used for adulteration of pepper, and are detected by the microscope. Sand, mineral matter, and palm nut powder may be detected by the absence of the brilliant yellow colour which pure pepper seeds assume on the addition of strong hydrochloric acid.

CLOTHING.

Clothing is largely a question of climate, habit, convenience, and civilisation, its function being to protect the body both from weather conditions and from injury, to assist its heat regulating mechanism, to ensure decency, and, more especially in the case of females, to adorn the outward person.

A well-clad body should possess its natural outlines, and be capable of performing its movements and functions without restriction, irritation, or injury, should be maintained at a natural and equable temperature, notwithstanding varying external conditions, and should not be an eyesore in the sight of man or beast.

Civilised garments are mainly manufactured from cotton, linen, wool, silk, indiarubber, paper, fur, feathers, leather, bone, and some metals.

Cotton.—The fibres of cotton microscopically are flat, twisted at short intervals, and present no nodes, joints, or branches (Fig. 80, *a*). Cotton cloth is hard, durable, does not shrink when washed, and does not readily absorb moisture. It is a good heat conductor, and has a small selective capacity for organic matter, though tenacious of odours. Nitric acid removes the twist from cotton fibres, and iodine stains them brown. Sulphuric acid gelatinises them.

Linen.—Flax fibres are round, broken up by nodes and joints, and are composed of filaments which here and there shred off as branches (Fig. 80, *b*).

Linen cloth is smooth, shiny, unshrinkable, does not readily absorb moisture, and is stronger than cotton, like which it is a good conductor of heat. It is not easily affected by strong alkalies or by acids, with the exception of sulphuric acid, which gelatinises it.

Wool.—Woollen fibres are round, colourless, and their surface resembles the scaly sides of a fish (Fig. 80, *c*). They do not branch, but when old become shredded and lose their characteristic imbricated appearance. Woollen garments are soft, warm, elastic, greedily absorb moisture, conduct heat badly, and do not retain odours. Wool is soluble in strong, hot alkali, is little affected by sulphuric acid, but gives the xantho-proteic reaction with nitric acid.

Silk.—The fibres of silk have each a central tube coated with an albuminous substance. Microscopically, they look like clear glass (Fig. 80, *d*). Silk is light, absorbs moisture, but to a less extent than wool, and is a bad conductor of heat and electricity. It is dissolved by strong alkali and acids, is distinguished from cotton and linen by its staining yellow with picric acid, and from wool by the absence of any darkening when it is steeped in an alkaline solution of lead oxide. The sulphur in wool causes it in such a solution to become dark. A mixture of silk, wool, and cotton may be differentiated by dissolving out the silk by means of strong chloride of zinc and washing, thereafter dissolving out the wool with strong, hot alkali: the cotton remains unchanged.

From what has been said, it will be apparent that wool is the best form of underclothing, being specially valuable in hot climates. It absorbs the perspiration, and by virtue of the animal fat it contains and the air interspaces

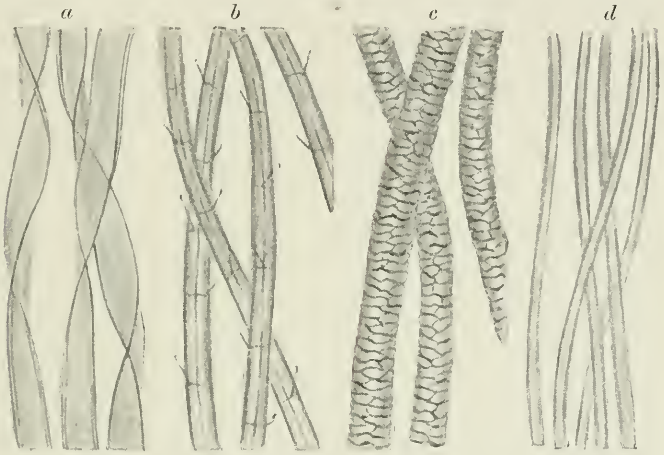


Fig. 80.—*a*, Cotton fibres. *b*, Linen fibres. *c*, Wool fibres. *d*, Silk fibres. × 100 diameters.

between its fibres, it keeps the body warm, preventing the loss of heat by evaporation.

Jaeger's woollen underwear and bed coverings are highly suitable for those exposed to our variable weather.

Flannel, a form of woollen material, can take up three times its weight of moisture, but is apt to irritate a tender skin.

Woollen garments, owing to their absorptive power, require frequent washing. They tend to shrink and become hard unless carefully cleansed in cold and tepid water with a soap free from excess of alkali, care being taken at the same time not to express the animal fat. Paraffin soaps are very useful for cleaning woollen goods.

Cotton worn next the skin tends to induce chill by becoming wet, and allowing evaporation of the moisture with which it has become saturated. Cotton is durable, does not shrink when washed, and conducts heat rapidly away from the body. If it be so woven as to include cellular interspaces in the material, it is much warmer and more suitable for underclothing.

Cotton forms a clean and useful external garment for those working indoors and coming in contact with much organic matter. Linen is inferior to cotton as a material for underwear, but is useful for collars, cuffs, and shirt-fronts, being white, clean, smooth, and easily glazed. Silk, though more expensive and less absorbent than wool, is superior to cotton and linen as a material for underclothing, except in the matter of durability. It is less rough, shrinks less, and is more cleanly than wool. Various mixtures of these materials are made, such as merino, a mixture of cotton and wool.

In hot weather and warm climates the netted undershirt of the Chinese, a light woollen or silken vest, prevents a garment soaked with a chilling perspiration from clinging uncomfortably about a cooling skin.

Outer garments, which are not so important hygienically as those worn next the skin, should, as far as possible, combine permeability to air with impermeability to water.

Waterproof clothing is uncomfortable owing to its impermeability to air, and endeavours have been made to provide a substitute for it by rendering tweed cloth less permeable to water while maintaining its permeability to air. This is done by soaking the cloth in solutions of certain salts, of which alum is the most commonly used. The superimposing of several layers of clothing one upon another keeps the body warmer than an equal thickness disposed in one layer. This is due to the air enclosed between the successive layers, air being a bad conductor of heat.

For outer garments, as for those worn next the skin, wool is the preferable material, and it must be remembered that dark colours have a greater selective property for organic matter than those which are light, and also absorb heat more readily. Hence the value of white clothing in the tropics and in the summer season. In the absence of more suitable material, layers of thick brown paper, disposed to form a padding, increase the warmth of the body, and have been found most useful by our troops when sleeping out on the high veldt. Fur, though very warm and impenetrable to rain, is a heavy and uncomfortable dress in any but the coldest climates; while feathers, as far as covering is concerned, find their chief use in beds. Leather is a suitable dress in cold climates, and is very durable, but has the same disadvantages as fur. Its most general application is, of course, in the shape of boots, which should conform to the anatomy of the feet and fit them closely, though permitting a natural position and free movements of the toes, especially of the big toe. Pointed boot toes, high heels, and rigid soles are fruitful sources of foot-weariness and deformity. The head-covering should be light, exert no pressure on the scalp, and, if not closely fitting, the space between it and the head should be ventilated; inattention to these details has more to do with the prevalence of baldness than is generally recognised.

On the whole, man's dress, except perhaps that of the medical profession, is a fairly rational and healthy costume, though knee breeches would be preferable to the trousers, oft-times bagging or overtight, employed in everyday life. In holiday garb and for military purposes, the puttee has advantages over stockings or gaiters, as it supports the calf, is not irritating, and is impervious to the bites of most insects. Of late years the dress of women has been greatly improved, especially by the substitution of the knickerbocker for the cumbrous petticoat, and the suspender for the garter. Further advantage would be derived if the stockings worn were always adapted to the weather, if the weight of petticoats and skirts were taken off the waist and hips, and applied instead to the shoulders, thus enabling a lighter corset to be worn, and also if the skirts less frequently fulfilled the functions of street sweepers. Tight-lacing is detrimental to the functions and positions of both the thoracic and abdominal organs, and interferes with the movements and shape of the locomotory system; the evils resulting from the habit have been little exaggerated. The wearing of furs and wrappers about the neck predisposes to sore throat. The question of head-dress for women is chiefly one of adornment.

The clothing of old people and children requires special attention. In the case of the latter, inequalities in warmth of the different parts of the body, so frequently observed, should be carefully avoided, but errors as great are made in swaddling and swathing naturally robust frames, and preventing the natural process of becoming inured to varying weather conditions. Dyes used in colouring clothing material should be innocuous, coloured stockings being most commonly at fault.

Night attire should be light, loose, and warm. As regards beds, in which so large a part of human life is spent, their coverings should also be light and warm. Delicate and rheumatic people should sleep between woollen sheets or blankets. Feather beds are insanitary; and hair mattresses should be made in three parts, as such an arrangement is always useful in case of sickness, and such a mattress lasts longer than the ordinary single stretch. The most hygienic bed is one with a metal open-work spring mattress, surmounted by a hair mattress, and free from all hangings and heavy woodwork above and below the bed. Free circulation of air about and below the bed is essential; and, as Sir Henry Littlejohn graphically puts it, the poor convict on his truss of straw, provided it be clean, is, from a hygienic point of view, better off than the duchess resting amongst the feathers of her canopied couch!

EXERCISE.

Exercise is essential to health, and to the maintenance and growth of the muscular tissues of the body. It aids in stimulating the vital functions, and brings about that much-desired condition, the *mens sana in corpore sano.* When a healthy person takes moderate exercise, his skin perspires, and evaporation from it is increased, thus ensuring no rise of temperature; his heart acts more rapidly and more forcibly, his circulation becomes more speedy, his respirations are increased in number and depth, and his respiratory exchange is magnified, there being a very large loss of carbon and increased absorption of oxygen. The appetite is improved and digestion benefited, as is mental vigour in the majority of cases. Indeed, the sedentary brain-worker, more than any one else, is braced and invigorated by muscular exertion in the open air.

Further, waste products are removed, especially from the muscles and the brain, though the excretion of water and salts by the kidneys is decreased owing to the free action of the skin. During exercise the excretion of nitrogen is diminished, but this, in all likelihood, is due to the deficient output of watery solvent. After exercise, the waste nitrogen, especially in the form of urea, is increased. The effect of exercise on the muscles is to increase the flow of blood both to them and from them, the efferent stream being darker and containing waste products. The muscles themselves enlarge and add to their nitrogenous elements, while their reaction from being neutral or alkaline becomes acid. A moderate amount of exercise increases intestinal peristalsis, but hard exercise may tend to lessen intestinal excretion, owing to the loss of water by the skin. Hard exercise diminishes the testicular secretion, the food being put to other uses than its manufacture; thus sexual desire is usually diminished in the athlete.

The benefits of exercise are enhanced if it be taken in the fresh air and at properly regulated periods, such as when the stomach is not loaded with food nor entirely empty. The body must be properly clad, or rather unclad, for it is an advantage to have as little clothing on as possible, and that little loose and absorbent. When the exercise is over, thorough cleansing of the skin and the donning of warm garments form precautions against chill.

As regards food, the man taking hard exercise may to a large extent indulge in his ordinary diet, though some excess in nitrogen, fat, and potash salts is indicated. Fat has been proved to be the best form in which to supply the carbon needed. Alcohol in any shape or form is bad, but water may be taken freely in small quantities at frequent intervals. Heavy smoking is distinctly injurious, owing to its sedative effect upon the circulatory and nervous systems. If exercise be taken indoors, it is important to have the ventilation as efficient as possible. While intermittent exercise, like intermittent pressure, causes hypertrophy of muscle; constant exercise, like constant pressure, eventually leads to atrophy. Consequently long periods of rest are necessary between violent bouts of muscular exertion, and too much strain should not be perpetually thrown on one group of muscles, but all should, as much as possible, be exercised alike. Man was meant to exercise in a natural manner, but it cannot be denied that he has sought out many devices which tend to specialise certain groups of muscles, as is the case in cycling. Natural exercises, such as walking, running, swimming, and riding, on the contrary, result in a more equal development of all the muscles of the body.

Exercise must be suited to age and sex in its variety and vigour. Exercise increases both the external and internal work accomplished by the body, the latter being the result of the accelerated circulatory and respiratory functions, and the former being the mechanical result of the output of energy.

We have previously referred (p. 220) to the relation which exists between internal and external work, and to the standard by which they are correlated. The amount of energy required to raise 1 ton 1 foot is termed a foot-ton, and in the case of a man of average weight doing moderate muscular work, the energy derived from the food and devoted to the internal work of the body, including the maintenance of heat, amounts to 2800 foot-tons daily. Of this 2800 foot-tons, one-tenth or 280 foot-tons represents the circulatory and respiratory work, and of it the circulatory claims six-sevenths, and the respiratory one-seventh. The external work which such an average man can accomplish amounts to 300 foot-tons per day; 400 foot-tons would represent a hard day's work, and few men are equal to a daily output of 500 foot-tons. To obtain a clearer view of the amount of ordinary exercise represented by 300 foot-tons, it is necessary to know, as Haughton has pointed out, that when walking on a level road at 3 miles an hour a man exerts an amount of energy equivalent to raising one-twentieth part of the weight of his body through the distance walked.

An unburdened man weighing 11 stones and walking 16·3 miles at 3 miles an hour, accomplishes 300 foot-tons of work. It has been found that walking at this rate the greatest amount of work can be performed with the least expenditure of energy. The fraction $\frac{1}{20}$ is known as the co-efficient of traction, and at greater speeds is increased. In mountain-climbing, the energy exerted is equivalent to raising the weight of the body to the height reached. In addition to the weight of the body, allowance must be made for extra weight carried in the form of clothes or burdens.

A formula by which the work done in walking can be calculated in foot-tons, is as follows :—

$$\frac{(W + W^1) \times D \times 5280}{2240} \times C = \text{foot-tons},$$

Where W = weight of the man in pounds.
,, W^1 = weight in pounds carried by the man.
,, D = distance walked in miles.
,, 5280 = number of feet in a mile.
,, 2240 = number of pounds in a ton.
,, C = coefficient of traction, *e.g.* $\frac{1}{20}$ at 3 miles an hour.

In ascending a height, the whole weight is raised, and no coefficient of traction enters into the calculation. Thus a man of 11 stones would do 300 foot-tons of work in ascending to an elevation of 4364 ft., or about the height of Ben Nevis, an exertion equivalent to walking 16 to 17 miles on the level. The ascent of Arthur's Seat, *i.e.* about 800 ft., would require of him 55 foot-tons of work, which corresponds to a walk of 3 miles. A healthy adult should daily undergo an amount of exercise equal to a walk of 9 miles on the level. Most men put in a certain amount of this exertion in their everyday work; but, with the exception of manual labourers, nearly all require more exercise than is performed by them as a result of the exigencies of their usual avocations.

For exercise to have its full effect, the action of the muscles must be consciously controlled by the brain. Muscle power and will power are intimately associated, as is known to every gymnast, and mere mechanical reflex contractions of the muscles can never have the same effect as when the mind is, so to speak, thrown into the exercise. This is one of the advantages of the Swedish system of gymnastics, another being the co-ordinated use of groups of muscles which in ordinary life are not much called into play, and of those muscles the regulated contractions of which will overcome the ill effects produced by deformity and disease.

BATHING.

"Cleanliness is next to godliness." The proverb, though hackneyed, is none the less correct in giving the habit of cleanliness an important place in man's welfare. True, just as an individual may become habituated to sin, and apparently suffer but little from its effects, so he may become habituated to dirt, and flourish in, and even enjoy, his filthy condition, as witness the old Scotch saying, "The clartier the cosier," without impairment of his usual health. His *usual* health, however, is not that of the cleanly person, and he renders himself predisposed to many diseases, and especially to infectious disorders and skin complaints. The whole body should be washed daily, a cold morning tub or sponge douche for the young and healthy, and a warm bath in the evening for those advanced in years, or with arterial degeneration, or who do not react to the stimulant effect of cold water. By a cold bath is here meant one the water in which has a temperature sufficiently below that of the body to cause a healthy reaction. If a complete bath or sponge cannot be obtained, special care should at least be taken to cleanse the feet, genitals, perinæum, buttocks, umbilicus, and axillæ. The Hindu custom of washing the anus after each defæcation is one to be highly commended.

A cold bath is technically one the temperature of which is below 65° F., a tepid bath in which it is between 80° F. and 90° F., a warm bath between 90° F. to 104° F., and a hot bath between 104° F. and 110° F. The addition of sea-salt or ammonia to a bath tends to render it more refreshing and stimulating. Sea-bathing owes its tonic and invigorating action even more to the surroundings and circumstances under which it is enjoyed than to the saline ingredients of the sea water. Undoubtedly the most thorough way of cleansing the skin is by a Russian or Turkish bath. The former is a steam, the latter a hot-air process, and both should be followed by shampooing, a cold douche, and a period of rest in a chamber with a moderate and carefully regulated temperature. The provisions of baths and cleansing wash-houses for the community at large is one of great importance, and constitutes a boon to those whose houses do not afford facilities for thorough personal cleansing. Local authorities are empowered by law to provide such means (see p. 559).

SEWAGE.

Source.—The term sewage in its broadest sense includes human excreta both solid and liquid, household waste waters, surface waters which contain street washings, and are therefore fouled by the excreta of animals, and effluents from trades and manufactures.

Human Excreta.—An adult male on an ordinary diet excretes daily 4 oz., by weight, of solid matter and 50 fluid oz. of liquid; but in a population of both sexes and all ages, the average daily excretion per unit of the population may be taken as $2\frac{1}{2}$ oz. of solid matter and 40 oz. of urine. Fresh fæces contain on an average 23·4 per cent. of dry solids, and fresh urine 4·2 per cent., of which about one-half is urea, and much of the remainder common salt. Knowing these figures, it is possible to calculate the weight of dried manure obtainable from the excreta of any population. The fæces and urine contain carbon, nitrogen, mineral matter, especially potash and phosphates, and residue of less importance. The carbon excreted by an adult male in these ways amounts to about 28 grms., and the nitrogen to 15 grms., but in a mixed population the nitrogen amounts to 10 grms., and the phosphates to 7 grms., per head per day. To these two, manure derived from excreta chiefly owes its value, though potash also adds to its richness. These analyses are those of fresh excreta; but when we come to deal with sewage we find that changes have taken place, especially if the fæces and urine have been mixed. In such a case the natural acidity of both is rapidly lost owing to decomposition of the urea, $CO(NH_2)_2$, of the urine, and the formation of carbonate of ammonia $(NH_4)_2CO_3$. The absorption of oxygen by the fæces is greatly increased, while gaseous and fœtid products of decomposition, both organic and inorganic, are evolved. If the temperature be high, such gases as carburetted hydrogen, nitrogen, carbonic acid, sulphuretted hydrogen, and ammonium sulphide are given off. The change in reaction and the gas formation are largely the work of micro-organisms, saprophytic organisms battening on the abundant pabulum afforded by sewage, and urea being converted into carbonate of ammonia by the *M. ureæ*. Pathogenetic micro-organisms find great difficulty in surviving in crude sewage, owing to their being crowded out by the hardier saprophytes. The cultural characteristics of the *Vibrio choleræ* and the *B. typhosus* tend to alter when these organisms are grown in sewage. The latter does not flourish in a sewage devoid of nitrates. In sewage there is found a certain amount of dissolved solids, suspended matters, both mineral and organic, organic carbon and nitrogen, ammonia and chlorides.

The Rivers Pollution Commissioners give the following as the average composition of sewage from a "water-closet" and a "midden" town :—

AVERAGE COMPOSITION OF SEWAGE (in parts per 100,000).

	Total Solids in Solution.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Total combined Nitrogen.	Chlorine.	Suspended Matters.		
							Mineral.	Organic.	Total.
Midden .	82·4	4·181	1·975	5·435	6·451	11·54	17·81	21·30	39·11
W.-C. . .	72·2	4·696	2·205	6·703	7·728	10·66	24·18	20·51	44·69

Manurial Value.—As, weight for weight, fæces are more valuable than urine, a dry sewage has a better market value as manure than one in which those ingredients are mixed. It is not practicable even in dry systems of collection and disposal of sewage to keep fæces and urine apart ; and since the daily output of urine much exceeds in weight that of fæces, the total urine excreted has a much higher value as a manure than the total fæces.

Theoretically, the average excrement per head per annum in a mixed population is worth about 7s., but practically this price is never realised by a community, owing to the admixture of substances having no agricultural value. Sewage collected by the water-carriage system is worth about 2d. per ton, and contains about 1 ton of solid matter in 850 tons.

EXAMINATION OF SEWAGE AND SEWAGE EFFLUENTS.

Sewage.—1. *Physical.*—A sample of crude sewage from a town with the water-carriage system is a grey, turbid liquid of more or less offensive smell, and containing solid suspended matter. On standing, a sediment collects at the bottom, and the proportion which this bears to the whole should be noted, and also the size of the particles which constitute the sediment. A scum may form on the top, and bubbles of gas may be disengaged and rise to the surface.

2. *Chemical.*—Sewage is submitted to the same analyses as water, with certain modifications.

Reaction.—The reaction of crude sewage of very recent origin is acid, but as usually examined it is alkaline, unless its reaction be altered by trade effluents.

Specific Gravity.—This is higher than 1000, but far below that of undiluted urine. The specific gravity of the sewage of any town is only slightly above that of the water forming the town's water supply.

Total Solids.—As in water (p. 196); but if there be much suspended matter, filter and estimate the solid matter in suspension and in solution separately.

Hardness may be tested as in water. It is high when thus estimated, mainly owing to the large quantity of chlorides present.

Chlorides.—As in water. The amount varies greatly, but is much in excess of that in water. Typical sewage contains 43 mgrms. per litre of chlorine, plus any chlorine present in the water supply.

Free Ammonia.—The process is the same as in water (p. 196); but, owing to the large amount of free ammonia obtainable from sewage, only a small quantity of sewage must be taken (1 to 20 c.c.), and that well diluted. A preliminary Nesslerisation with a little filtered sewage may serve as a guide to the amount to be used for distillation. The addition of freshly-fused sodium carbonate aids the distillation and makes certain that the sewage has an alkaline reaction. The average amount of free ammonia varies within wide limits, but is frequently from 5 to 6 parts per 100,000. Unlike water, there is more free ammonia than albuminoid ammonia present.

Albuminoid Ammonia.—As in water; but when adding the permanganate dilute further with ammonia-free water, as the test is lengthy, and the contents of the flask may otherwise dry up. It may amount to ·3 to ·4 parts per 100,000.

Nitrites and Nitrates.—These are not usually abundant in crude sewage, being rapidly reduced to ammonia. They may be estimated as in water.

Organic Matter.—(*a*) *In terms of oxygen absorbed.*—(1) As in water, but the quantity of sewage used must be very small (20 c.c.). (2) Another method (Adeney's process) is to find the amount of oxygen which a given quantity of sewage will absorb from atmospheric air with which it is in contact. A clear portion of sewage is taken, and if strong it is diluted. It is then placed in a large bottle and allowed to come to the temperature of the surrounding air. The bottle is then sealed and placed in the dark for three or four days. The quantity of oxygen in the air is determined before and after the experiment, and the difference observed, the temperature and pressure being noted. (3) Wanklyn and Cooper's moist combustion process, in which the sewage is boiled with caustic potash and excess of permanganate of potash, and the quantity of permanganate used up by the organic matter is estimated by the aid of sulphuric acid and protosulphate of iron, which remove the colour remaining in the undecomposed permanganate. The permanganate solution is one of which 1 c.c. is equivalent to 1 mgrm. oxygen, and the result in terms of the oxygen absorbed is stated as mgrms. per litre.

(*b*) *In terms of nitrogen*, from the amount of ammonia given off by the action of sulphuric acid and heat. This is Kjeldahl's process, as in water, but an extremely small quantity of sewage is used.

(*c*) *In terms of carbonic acid and nitrogen*, obtained by Professor Hunter Stewart's process. As in water, but only a minute quantity of sewage is employed.

Gases in sewage.—These are those contained in atmospheric air, but exist in very different proportions. There may be little or no oxygen, that gas being rapidly used up in the oxidation of organic matter. The proportion of nitrogen to oxygen is much greater than in water. Carbonic acid is the chief gaseous constituent of sewage. It frequently amounts to 100 c.c. per litre, in addition to what was originally present in the water diluting the sewage. The decomposition of sewage results in the formation of other gases, such as ammonia, marsh gas, sulphuretted hydrogen, etc.

3. *Bacteriological.*—Little can be learned from a mere microscopical examination of sewage, and it is necessary to carry out a qualitative and quantitative bacteriological test.

Qualitative.—The important point is to make a sufficient dilution, and obtain plates which are not inconveniently crowded. The common organisms of sewage are *Beggiatoa alba*, *Bacillus coli communis*, *B. denitrificans*, *B. enteritidis sporogenes*, *B. filamentosus*, *B. fluorescens liquefaciens;* granular sewage organism of Klein, *B. lactis aerogenes* and *cyanogenus*, *B. liquefaciens*, *B. megatherium*, *B. proteus vulgaris* and *zenkeri*, *B. putrificus coli*, *B. thermophilus*, and *M. ureæ.* The salient points are, the number of liquefying organisms commonly present, the profusion of *B. coli communis* and of *proteus* with its alkaline reaction, and the invariable presence of the anaerobic and spore-bearing *B. enteritidis sporogenes.* The last-named organism is isolated by adding a small portion of the sewage to a tube of sterilised milk, heating it to 80° C. for fifteen minutes, and thereafter incubating at 37° C. anaerobically in a Buchner's tube.

Quantitative.—The number of organisms present per c.c. of sewage varies from about 1,000,000 upwards. The method of calculation is the same as that in water, but the sewage requires very free dilution.

Sewage Effluents.—A sewage effluent is the fluid portion of the sewage after the sewage has been subjected to a process of purification (p. 386). Effluents are analysed by the same methods as sewage, but rarely require such extensive dilution. In comparing an effluent with the sewage from which it has been derived, it is essential to adopt the same tests for each.

The purity of sewage effluents may be judged by various tests, of which the incubator test is the most important. A good effluent should be so thoroughly oxidised that it does not absorb more oxygen after incubation for one week than it does at the time of collection. The organic ammonia in an effluent should be less than ·1 per 100,000 parts, and the nitrogen as nitrates should exceed ·5 parts per 100,000 if the purification of sewage by land or filters is efficient. A rapid test of purity is the persistence of froth on shaking the effluent for the space of one minute in a bottle half full; the froth should not last more than three seconds if the effluent be good.

SEWAGE AND DISEASE.

Fresh sewage has but little relation to the causation of disease provided it be free from pathogenetic micro-organisms. True, the *B. enteritidis sporogenes*, which is constantly present in sewage, may occasionally produce irritant intestinal symptoms should it gain access to food, but such contamination seldom occurs from fresh sewage. Stagnant sewage, on the other hand, even if free from pathogenetic micro-organisms, may, by its foul emanations, predispose to specific disease, though not itself the causa causans. Mephitic poisoning, even with fatal results, has occurred as the result of the opening of old cesspools and blocked drains. The chronic symptoms produced by sewer gas are headache, sore throat, anorexia, nausea, and general lowering of vital vigour; these predispose to such diseases as diphtheria, puerperal fever, erysipelas, and enteric fever. Sewage constantly contains the *B. coli communis*, and though, as far as is known, this microbe is not the cause of any specific fever, it may by symbiosis aid the action of the *B. typhosus*.

A dysenteric outbreak has been attributed to the spreading of sewage on land adjacent to and on the windward side of an asylum, but this was probably not the real cause of the dysentery, as similar outbreaks have since occurred in other asylums under different conditions. If the sewage be not allowed to stagnate, and the sewer be well ventilated, it has been found that sewer air differs but little from atmospheric air, and contains few micro-organisms. A stagnant and fermenting sewage, on the other hand, by reason of the constant bursting of bubbles on its surface, may possibly project micro-organisms into the surrounding air, but opinions differ on this point. It has been suggested that moist air from sewers rising to ventilation outlets, and there meeting with the cold external air, may produce a mist, on the droplets of which bacteria might be borne some distance from the sewer. The specific diseases with which sewage is more particularly associated are cholera, enteric fever, diarrhœa, and various parasitic disorders. As a rule, the infected sewage operates through the medium of drinking-water, but food-stuffs may be contaminated by it, and dried sewage dust may convey the virus. There is no evidence that a well-managed sewage farm is a source of disease, but if the farm be badly placed, as on the summit of an old anticline in which the outcrops of porous strata are laid bare (Fig. 63, p. 178), or if it be inefficiently drained, permitting the ground to become marshy, water supplies may be contaminated.

The Edinburgh sewage farm at Craigentinny Meadows is now in a bad position, being almost surrounded by the city, and consequently it is said by the chief sanitary inspector to be a nuisance on account of its organic effluvia, even although there is no connection between it and outbreaks of communicable disease. Since the general introduction of sewers, and the adoption of the water-carriage system in preference to other methods of sewage collection and disposal in large towns, the death-rate from enteric fever has fallen very considerably, the conditions favouring the spread of cholera have been greatly lessened, and, owing to the drainage operations having rendered the soil less damp, other benefits have accrued. It is worthy of note that in the same period diphtheria has changed its incidence from a rural to an urban disease, but how far these facts are related to one another is uncertain, and the question has received but little attention.

INFECTION.

By infection is meant the production of lesion or disease in the body through the agency of bacteria; those bacteria capable of so doing are termed pathogenetic. In one sense many bacteria are pathogenetic, as even those commonly regarded as harmless, if injected into an animal in huge doses, will produce inflammation. Irrespective of dosage, however, and from the point of view of their effect on the human system, bacteria may be classed into six groups—

(*a*) Those which, when present in the human body, are always accompanied by morbid symptoms, *e.g. B. anthracis*.

(*b*) Those which, when present in the human body, usually manifest themselves by producing disease, but may exist without causing any morbid symptoms, *e.g. B. typhosus*, which has been found quiescent in the gall-bladder years after an attack of enteric fever.

(*c*) Those which inhabit portions of the body in contact with the outer air, and are usually pathogenetic, but may remain quiescent until some lowering in vitality enables them to produce morbid change, *e.g. B. diphtheriæ*, *Pneumococcus*.

(*d*) Those which normally exist outside the body, and, on gaining access to it, cannot produce lesion or disease unless their action is aided by another organism or by some local condition, such as an impaired tissue vitality, *e.g. B. tetani*.

(*e*) Those which under ordinary conditions live in the human body and do not tend to produce disease, but which, under peculiar and favourable circumstances, become pathogenetic, *e.g. B. coli communis*.

(*f*) Those which are either normally present in the body and never produce disease or lesion, or which, when introduced into it from without, fail to do so, steadily disappearing from the tissues, *e.g.* most saprophytic organisms.

Sources and Channels of Infection.—The sources of infection are the soil, air, water, food, animals, and man, since all of these may harbour or contain the materies morbi, and may indeed form its natural habitat. The channels of infection in the human body may be regarded as—(*a*) extramural; (*b*) intramural.

(*a*) The former are the methods by which the virus gains access to the body, and are the air, food including water, fomites, soil including dust, insects, the secretions and excretions of lower animals and man. The systems by which entry is effected are the alimentary, respiratory, and cutaneous, while the mucous membranes of the eye, urethra, and vagina are also vulnerable.

(*b*) The latter are the methods of distribution within the body, and may be by direct continuity, or by the blood or lymph streams.

The pathogenetic organism having gained access to the body, what is its further fate?

(1) It may fail to develop owing to the vitality of the tissue in which it finds a lodgment.

(2) It may remain localised at the point of entry and produce entirely local effects, *e.g.* stitch pustule.

(3) It may remain local, but produce poisons which pass into the system, *e.g. B. diphtheriæ*, *B. tetani*. In the former of these diseases, in addition to the action of the circulating toxines, there is a severe local necrotic process; in the latter, the local effects are of the slightest.

(4) It may pass into the body by any of the intramural channels, invade different parts of the body, and there give rise to poisonous principles. Bacterial intoxication is probably due to a concatenation of poisons, some of which may be produced alike by many different bacteria, *e.g.* pyrotoxin; others may be specific and owe their origin to only one species of bacterium.

What does its fate depend on? It depends on—(*a*) The nature of the organism, whether or not invasive. (*b*) The nature of the defence. The resistant power of the tissues invaded. (*c*) The number of organisms forming the attack; and (*d*) their state of efficiency with regard to virulence. (*e*) The presence or absence of allies, in the shape of other organisms assisting the attack or defence. (*f*) The reinforcement of the defence by preventive inoculation, curative sera, surgical interference, or drugs.

(*a*) Some forms of pathogenetic organisms themselves invade the blood stream, producing a general septicæmia, *e.g.* anthrax. As pointed out, Löffler's bacillus may devastate the tissues in which it is situated, and send its myrmidons, in the shape of toxines, throughout the body, while the bacillus of tetanus is content with the latter form of attack. On the other hand, there is the non-invasive organism, which entrenches itself in pus and makes no general invasion.

(*b*) The nature of the defence offered may be either feeble or vigorous. Weakness of the defence may be due to a predisposition to invasion, thus the negro race is very susceptible to smallpox, and makes but a feeble fight against its ravages; while the invasion of the *B. typhosus* is less resisted by the young than by the old. Further, a weak defence is offered if there be a general lowering of vitality from starvation, want of light, overcrowding, etc. A community labouring under such disadvantages is readily invaded by typhus fever. The defence may be weak at one spot, where it may chance the attack is developed, *e.g.* an abrasion of the skin facilitating the invasion of tetanus. A vigorous defence may be due to an insusceptibility to invasion termed natural immunity, *e.g.* the black races are much more resistant to yellow fever than other races, and people who have reached adult age without an attack of whooping-cough then rarely take it. A person in robust health offers a more strenuous resistance to invasion than one whose vitality is in any way lowered.

(*c*) An overwhelming number of organisms may take part in the invasion and completely swamp all defence, *e.g.* a streptococcal infection producing rapid general septicæmia. The attack may be made in moderate force, and result in a stiff fight and a brisk reaction, *e.g.* erysipelas due to streptococci. Finally, the organisms may be in such small numbers as only to cause slight local lesion, *e.g.* furuncle due to streptococcus.

(*d*) Though only a small number of organisms may participate in the invasion, their attack may be so deadly that the defence is at once overpowered, *e.g.* malignant scarlet fever; while, conversely, the virus may be so impotent as to be easily combated, *e.g.* benign scarlet fever.

(*e*) The defence may be strengthened by allies in the shape of antagonistic micro-organisms weakening the attacking force, *e.g.* pyococci weakening and lessening the virulence of the *B. anthracis* (*non-specific immunisation*). The assault may be strengthened or rendered possible by the co-operation of other organisms. This effect may be produced in five ways—(1) The ally may act independently, the invasion being made by both organisms contemporaneously, with the result that the available defence against either is decreased, *e.g.* scarlet fever and diphtheria. (2) The allied forces may intensify each other's attack, the attack being a failure unless they are combined. This is termed obligatory symbiosis, and is exemplified in the ginger-beer yeast plant, which can only exist and produce fermentation when combined with a bacillus. (3) The allied forces may intensify each other's attack, but their alliance is not essential, *e.g.* tetanus and the pyogenetic organisms. This is termed facultative symbiosis. (4) The allied forces may overcome the defence by attack separately in succession, the first being successfully resisted by the defence, but at such a cost that the second force easily gains a footing (*secondary infection*). This is illustrated by tuberculosis following an attack of measles or pneumonia, and by pyogenetic cocci producing suppuration during convalescence from typhoid fever. (5) Possibly the main attack may be supplemented by the non-combatants of the garrison rising in revolt. Thus there is some evidence to show that the *B. coli communis* during an attack of enteric fever may become pathogenetic.

(*f*) The defence may be reinforced in several ways, thus—(1) The enemy (organisms) or its myrmidons (toxines) may, purposely or not, be allowed to invade the disputed fortress wherein they are overpowered, and as a result the defence benefits by having conferred upon it an immunity from further, and possibly more severe attack (*specific immunisation of the active form*). This is illustrated by the rarity of a second attack of most of the exanthemata, and, before the days of vaccination, was exemplified in the inoculation of smallpox as a preventive of that disease. Antityphoid inoculations also come under this category, though the reaction is not very severe. It consists in the injection of dead bacilli and such products as are contained in them and the fluid in which they have been cultivated. Antirabic inoculations likewise participate in the principle of producing a specific active immunity, though the precise nature of the virus is not thoroughly analysed. Vaccination against smallpox is practically another example of this method, if cowpox be, as is reasonably supposed, merely smallpox in the cow. In this instance the enemy is weakened prior to admission to the fortress, so that the effects of its invasion are slight. (2) The reinforcement may take the shape of what may be called a stiffening with veterans; in other words, the defence is strengthened by receiving a portion of another garrison which has successfully encountered and overcome the enemy in the way described under the first form (*specific immunisation passive*). This is illustrated by the use of the diphtheria antitoxin obtained from the blood serum of an immunised horse, and which, injected into a person suffering from the disease, strengthens his resisting power. The use of tetanus antitoxin is another example. [It is beyond the scope of this book to enter into a discussion of the difference between antibacterial and antitoxic sera, the preparation of such sera, the laboratory methods of immunisation, and the theories regarding the real nature of immunity.] (3) The defence may be saved from the development of an attack by a blow struck by an ally at the enemy immediately upon invasion (*surgical interference*). *Example.*—The early use of the cautery or caustic at the seat of inoculation in such a disease as rabies. (4) The defence may be aided by frequent reinforcements of allies, which may themselves powerfully combat the enemy, or may merely strengthen the garrison for the fight, or repair the losses which it has incurred (*drugs, stimulants, and nourishment*). As an example of the first action may be cited the exhibition of quinine in malaria, which has a lethal effect on the plasmodium causing that disease.

Such, then, are the factors determining the fate of the pathogenetic organism after it has gained access to the body. Fortunately, in our endeavours to compass its destruction, we are not limited to efforts at this stage. We can combat the virus during its existence ex corpore. This is where the forces of hygiene play their special part. They may achieve their purpose by actual attack upon the enemy (*disinfection*), by hampering its movements and cutting off its supplies (*quarantine and isolation*), by an efficient intelligence department (*notification*), or by placing the garrison under such conditions as to baffle invasion or render it futile.

Preventive inoculation as in plague and enteric fever, vaccination as in smallpox, the drainage of the soil, the destruction of refuse, the introduction of systems of sewerage and sewage disposal, the erection of healthy houses, the provision of light and of pure air, the prevention of smoke, the lavish supply of pure water, the erection of baths and wash-houses, the inspection of food-stuffs and the regulation of their sale, are all means whereby the latter objects are attained.

DISINFECTION.

Disinfection is performed by means of what are known as disinfectants, but, as popularly used, this is a very loose term. By a disinfectant is meant an agent which, in virtue of its own inherent qualities, is capable of destroying those pathogenetic micro-organisms which are the causes of communicable disease. Anthrax spores are taken as the test organism on account of their great viability. The term disinfectant is extended to include both antiseptics and deodorants which, as ordinarily used, are not lethal to micro-organisms. An antiseptic is an agent which inhibits microbal growth, prevents decomposition, and, if used sufficiently concentrated, is capable of killing bacteria, and so acting as a true disinfectant. A deodorant is an agent which merely reduces, oxidises, or absorbs the products of decomposition, and destroys or conceals evil odours.

Disinfectants are *chemical* and *physical*, and the chemical disinfectants are divided into solids, liquids, and gases. It will, however, be at once apparent that, in order to come properly into contact with the organism it has to destroy, and in order to possess that penetrating power which is essential, a chemical disinfectant must be used in a fluid or gaseous form.

The ideal chemical disinfectant should be—(1) non-poisonous to man and animals; (2) non-corrosive to metals; (3) harmless to colours and to leather articles; (4) readily soluble in cold water; (5) capable of conversion into a gaseous disinfectant; (6) powerfully lethal to bacteria and their spores; (7) rapid in action; (8) free from offensive odour; (9) cheap.

LIQUID DISINFECTANTS.

Solutions of the following substances are employed :—

Perchloride of Mercury ($HgCl_2$).—Corrosive sublimate. This salt is readily soluble in water, especially if the water be hot, and forms a colourless non-odorous solution.

Advantages.—It is a very powerful disinfectant, being directly lethal to bacteria and coagulating their protoplasm. It is also cheap.

Disadvantages.—It is very poisonous to man, corrodes metal, and its solution is colourless and without smell. It forms with albumin an insoluble inert albuminate of mercury. Some of these disadvantages may be remedied. Thus its resemblance to water may be obviated by adding colouring matter to it, and the formation of inert albuminate may be prevented by acidulating the solution, or less effectually by the addition of other chlorides. The solution recommended by the Local Government Board contains corrosive sublimate $\frac{1}{2}$ oz., hydrochloric acid 1 oz., anilin-blue 5 grs., water 3 gallons.

This contains too much anilin-blue, 1 gr. being more than sufficient. It contains about 1 part of corrosive sublimate in 960 parts. Corrosive sublimate is sold in the convenient form of tablets, which should be coloured. As an antiseptic it may be used in such diluted strength as 1 to 5000, but in order to kill micro-organisms a strength of 1 to 1000 is required, and such a solution destroys the bacilli of anthrax, diphtheria, glanders, enteric fever, and the vibrio of cholera in ten seconds; a strength of 1 to 500 is required to kill spores, and probably anthrax spores require an even stronger solution.

Mercuric Iodide (HgI_2).—This is even more powerful than the perchloride, less poisonous, and does not tend to coagulate albumin to the same extent. It has the disadvantage of being insoluble in water, except in the presence of iodide of potassium, and, like the perchloride, it corrodes metals. It is efficient in weaker solution than the perchloride.

Phenol. Carbolic Acid (C_6H_5OH).—This is readily soluble in water, but commercially it is impure, and contains tar oils. It is poisonous, caustic, and coagulates albumin. It is probably the most universally employed disinfectant, and must be used in at least a 5 per cent. solution, which is effectual against ordinary bacteria, and possibly also against spores if the period of contact be not less than twenty-four hours. Carbolic acid enters into the composition of numerous deodorant powders and cleansing soaps which cannot be regarded as true disinfectants.

Izal is obtained from a tar oil of unknown composition, and is a dark-brown liquid having a characteristic "sheep dip" smell, and forming a creamy emulsion with water. It is stated to be non-poisonous, and is cheaper than pure carbolic acid. It has been largely used in the disinfection of enteric stools during the South African War, and has the advantage of being very obnoxious to flies. It is best used in a strength of 5 per cent., but 1 per cent. is effectual if more time is allowed for its action. Allied substances containing cresols like those of carbolic acid, are Jeyes' fluid, okol, creolin, saprol, and lysol: the last named is excellent for hand-cleansing purposes, as it does not roughen the skin, and it appears to be twice as powerful as carbolic acid.

Formic Aldehyde ($CHOH$) is used as formalin, a 40 per cent. aqueous solution of formic aldehyde, which in its natural condition is a gas. Formalin possesses a slightly irritant odour, is cheap, and is a rapid disinfectant. It is harmless to colours and to metal work with the exception of iron, and is conveniently used in the form of a fine spray. It can be used to disinfect books and boots. A ·5 per cent. solution of formalin destroys most organisms, and it is commonly used in a strength of 1 to 2 per cent.

Chinosol is a yellow crystalline powder with a slightly aromatic odour which belongs to the quinolin group (C_9H_7N) of the coal-tar series. It is non-poisonous and non-corrosive, is readily soluble in water, does not coagulate albumin, and is a powerful disinfectant, being about the same strength as corrosive sublimate. Alkaline water or soap interferes with its action, and iron articles are discoloured. For this reason plated instruments should be used with it, and it should be kept in glass or china vessels. It must not be used with perchloride of mercury, since both disinfectants are thereby rendered inert.

Chloride of Lime.—Bleaching powder ($CaCl_2Ca(ClO)_2$), as its formula shows, is a mixture of chloride and hypochlorite of lime. Its efficacy depends on the amount of available chlorine which it contains, and this should be at least 30 per cent. It is a greyish powder with a disagreeable smell, and may be made into a cream with a little water, and then diluted as required. The solution corrodes metals, and dissolves albumin. It is used for spraying or washing in a solution of 1 per cent., and acts best if a little acid be added, or if the temperature be raised. The chlorine is liberated in a nascent state.

Hypochlorite of sodium and chloros (which contains 10 per cent. of available chlorine) are preparations analogous to bleaching powder, and, like it, should be kept in a dark place.

Iodine has powerful disinfectant properties, but finds its use in therapeutic rather than hygienic disinfection.

Sulphate of Iron ($FeSO_4 + 7H_2O$) or green copperas, when used as a disinfectant, must be in 30 per cent. solution.

Sulphate of Copper ($CuSO_4 + 5H_2O$), or blue vitriol, is soluble in water, poisonous, and coagulates albumin. It is a powerful disinfectant in 5 per cent. solution.

Chloride of Zinc ($ZnCl_2$) resembles copper sulphate in its disinfectant action. Burnett's fluid, long used in the navy, contains about 50 per cent. of chloride of zinc.

Potassium Permanganate ($KMnO_4$) is soluble in water, and is a disinfectant if the solution be very concentrated, but in this condition there are three disadvantages,—it is expensive, it produces stains, and it is too easily reduced to an inert form.

GASEOUS DISINFECTANTS.

Formic Aldehyde, besides its use as a liquid, is a valuable disinfectant in the gaseous state.

If formalin (40 per cent. solution of formic aldehyde) be evaporated in an open dish, vapours of formic aldehyde are obtained, but some paraformaldehyde, a solid polymeride, is also produced, and thus the quantity of gas obtained is uncertain. Hence special apparatus has been devised. That of Trillat consists of an autoclave, in which the formalin is heated with calcium chloride. The formic aldehyde gas is liberated without admixture of steam, for the addition of the chloride of calcium has so raised the boiling point of the mixture that the aqueous portion of the formalin is not liberated as steam at the temperature at which the formic aldehyde volatilises. When a pressure of three atmospheres is attained, the gas is allowed to escape, and conducted to the place to be disinfected. The method is expensive, lengthy, and complicated. Schlossmann has advised the use of glycerine with the formalin, with the object of obtaining volatilisation without the formation of the solid. Paraformaldehyde may be used as the source of formic aldehyde vapour. In the Breslau method, the paraformaldehyde is obtained by the concentration of a dilute solution of formalin by the combustion of spirit. The quantities of formalin, the dilution, and the amount of spirit, require careful adjustment, and the air must contain sufficient watery vapour to ensure the efficiency of the volatilisation. Schering devised a lamp by which paraformaldehyde might be heated in the presence of water vapour, and give off formic aldehyde gas.

The most recent and best form of lamp for this purpose is that known as the hydroformant, which holds 12 oz. of water. The paraformaldehyde is used in the form of tablets, which volatilise as the water is converted into steam. Not less than five 1-grm. tablets should be used for every 100 cubic ft. of area to be disinfected; this quantity is effectual even for anthrax spores.

Another source of formic aldehyde gas is methyl alcohol or wood spirit. The alcohol is volatilised, and in contact with hot platinum, in the presence of air, oxidises into formic aldehyde. The best lamp for this purpose is the Formogène-Richard, but the process is expensive and not adapted for general use.

Chlorine (Cl) once held the foremost place amongst gaseous disinfectants, but has been superseded by formic aldehyde and the less efficient sulphurous acid. It is a greenish-hued, irritating gas, which is very heavy, diffuses badly, and is useless as a disinfectant in dry air. It liberates oxygen, bleaches organic colouring matter, and is a powerful deodorant, but in large quantities is a somewhat expensive disinfectant. It is best generated by the action of an acid on bleaching powder.

1. $CaCl_2Ca(ClO)_2 + 2H_2SO_4 = 2CaSO_4 + 2HCl + 2HClO$ (hypochlorous acid).

2. $2HCl + 2HClO = 2H_2O + 2Cl_2$.

1 to 2 lb. of bleaching powder, with half its weight of acid, are sufficient to disinfect 1000 cubic ft. of space if the air be moist.

Sulphurous Acid (SO_2).—This gas has been in official use as the most convenient gaseous disinfectant for many years, though now formic aldehyde shares its popularity. It is a reducing agent, and takes up oxygen to form SO_3, which unites with water to form sulphuric acid (H_2SO_4). It is cheap, and easily evolved by the combustion of sulphur. It is heavy, diffuses badly, is very irritating to mucous membranes, has only a slight bleaching action, and a feeble disinfectant power if the air be dry. In the presence of moisture, however, it becomes a powerful disinfectant, and a 5 per cent. solution in water is lethal even to anthrax spores. The inefficiency of sulphur disinfection is frequently due to neglect to first thoroughly moisten the surfaces with which the gas is to come in contact, and, as a rule, the quantity of sulphur burned is insufficient for the area to be disinfected. The air must not contain less than 2 per cent. of sulphurous acid, if disinfection is to be attained. The gas may be generated by various methods—

1. Rolled sulphur may be used in the form of small pieces, moistened with alcohol to render combustion more complete, and ignited. 2 lb. of sulphur are required for every 1000 cubic ft. of space.

2. Sulphur candles are now prepared, in which the sulphur is mixed with other materials to facilitate complete combustion.

3. Carbon bisulphide yields sulphurous acid on combustion, and may be burned in a benzoline lamp for disinfecting purposes. The equation is—
$CS_2 + 2O_2 = CO_2 + SO_2 + S$.

4. Sulphurous acid gas may be liquefied under pressure, and stored in metal cylinders; it returns to the gaseous state on liberation from pressure. Two cylinders are required to provide 2 per cent. of SO_2 to every 1000 cubic ft. of space.

Nitrogen Tetroxide (N_2O_4) is obtained by the action of nitric acid on copper shavings, in the presence of water; nitric oxide is given off, and combines with the oxygen of the atmosphere to form reddish fumes of nitrogen tetroxide—

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO + 4H_2O.$$
$$2NO + O_2 = N_2O_4.$$

Nitrogen tetroxide parts with some of its oxygen to oxidisable matter, and is reduced to nitric oxide, which again obtains oxygen from the air.

3 oz. of nitric acid and 3 oz. of water mixed and poured on to 1 oz. of copper shavings suffice for 1000 cubic ft. of space.

PHYSICAL DISINFECTANTS.

Fresh air, sunlight, fire, and heat form the physical disinfectants.

Fresh Air.—Slow in action, but powerful in result. Its effects are due to the oxygen it contains, and are greater if that oxygen be in a nascent state, as is the case when the air contains ozone.

Sunlight.—The value of sunlight, in conjunction with fresh air and moisture, must not be underrated, although probably the spores of bacilli resist their combined action.

The valuable rays of sunlight are the actinic rays appertaining to the violet and ultra-violet end of the spectrum of sunlight; the infra-red rays are not so valuable. The disinfectant action of sunlight is possibly due to the formation, in the presence of air and water, of small quantities of ozone and peroxide of hydrogen, which have strong powers of oxidation.

Fire.—Destruction by fire is, of course, the most thorough means of disinfection, and, wherever possible, should be employed, as for articles of little value and for infectious stools.

Native huts and hovels, which are cheap and easily reconstructed, are often best disinfected by fire, especially in such diseases as the plague, where the soil forms a nidus for the organism.

It was undoubtedly the purifying influence of fire that freed London from the great epidemic of plague, which commenced in 1665.

Heat.—The methods of heat disinfection are by boiling, hot dry air, and steam. *Boiling* is an efficient means of disinfection for most organisms, but a few of the more resistant are not destroyed by it unless it be prolonged. For spore-bearing organisms, fractional boiling, as first pointed out by Tyndall, must be employed. The intervals between the boilings allow the spores to develop into the less resistant bacterial forms, in which they are successively and successfully killed.

The disadvantage of boiling is that it is apt to fix albuminous stains, and if it be employed, *e.g.* for clothes, these must first be soaked in cold water, washed with soap or soda, and then boiled for half an hour. The water in which they have been soaked and washed must also be disinfected by boiling.

Hot Dry Air.—For practical disinfection this method is now discredited, owing to its many disadvantages, namely—(1) the heat has a tardy and feeble penetrating power; (2) it is difficult to obtain an equal distribution of the heat; (3) damage to fabrics is apt to result if a sufficiently high temperature be attained; (4) it fixes stains, melts fusible materials, and renders many articles brittle; (5) danger of fire.

Its advantage lies in—(1) its economy; (2) its ready employment in emergencies, *e.g.* a baker's oven may be utilised for the purpose; (3) it does not destroy such articles as leather, fur, and bound books. The temperature required is, at least, 110° C.; higher temperatures may scorch or otherwise damage goods by destroying their elasticity and gloss. The best known apparatus for the purpose is Ransom's, which consists of an iron chamber lined with wood and felt, and heated by a gas burner. Thermometers are inserted in the inlet and outlet flues, the former of which conveys the hot air and products of combustion to the chamber, which they enter through a perforated plate. The amount of heat is regulated automatically, and there is a precaution against fire in the event of the temperature reaching 150° C.

Steam.—Disinfection by means of moist heat is superior to the use of hot dry air for several reasons :—

1. The large amount of latent heat in steam. Steam in contact with the article to be disinfected, which is at a lower temperature than the steam, undergoes condensation, and in the process parts with its latent heat, thus increasing the temperature of the article. When steam condenses into water, it parts with latent heat to the amount of 893·7 units for every pound of water which was originally converted into steam. Hot dry air, on the other hand, has no latent heat, but, on the contrary, has its temperature reduced, owing to the fact that before the temperature of the article can be sufficiently raised, any moisture it contains must be evaporated, and the process of evaporation uses up a certain quantity of heat.

2. Its high penetrative power. The condensation of steam is accompanied by a diminution in volume, and the creation of a partial vacuum in the interstices of the article under disinfection. To fill up this vacuum, more steam rapidly presses forward, and in its turn undergoes a like process, until every part of the article is thoroughly penetrated by the steam. The penetration of hot dry air, on the contrary, depends entirely on the processes of conduction and convection, and dry air is a slow conductor of heat. Further, the diminution in volume of hot dry air, by loss of heat, is trifling compared to that produced in the condensation of steam.

3. A lower temperature continued for a shorter time suffices for adequate disinfection.

4. There is less risk of fire and of injury to most fabrics and materials.

Disadvantages of moist heat.—1. The apparatus required is expensive, and requires skilled attention.

2. Possible damage to fabrics, such as shrinking, removal of natural grease, and discoloration of flannel and woollen goods ; loss of surface glaze in cotton, linen, and silk ; destruction of leather materials, as regards texture and pliability, fixing of stains, and " running " of colours.

Application of Steam.—For disinfectant purposes, steam may be employed under the following physical conditions :—(*a*) saturated, (*b*) superheated. By saturated steam is meant steam the temperature of which corresponds to the pressure under which the steam is formed. Under ordinary atmospheric pressure (15 lb. to the square inch), water becomes steam at a temperature of 100° C., and this steam is saturated steam. At higher pressures the boiling point of water is raised, and steam is formed at a higher temperature than 100° C. As, however, pressure and temperature still correspond, the steam remains saturated steam. It will therefore be apparent that the temperature of saturated steam is not always the same. By superheated steam is meant steam the temperature of which is higher than that which corresponds to the pressure under which the steam is formed. It is obtained—(1) By increasing the temperature of saturated steam without altering its pressure, so that these no longer correspond. This can be done by enclosing the saturated steam in a chamber surrounded by a hollow wall, into which steam at a higher temperature is admitted. (2) By impregnating the water from which the steam is to be obtained with calcium chloride, which raises the boiling point of water at ordinary atmospheric pressure. Hence steam is formed at ordinary atmospheric pressure, but at a temperature which does not correspond to this pressure.

There is an important difference as regards the condensation of saturated and superheated steam. The former may be said to be constantly on the brink of condensation, and the least lowering of temperature results in the steam changing into water. The latter will not be anywhere near condensation until its temperature has been reduced by conduction to such an extent that it has become saturated steam. When in this condition, the slightest further lowering of temperature will immediately bring about condensation. Saturated steam, therefore, resembles a vapour, and superheated steam a gas. Thus, if steam is in contact with the water from which it is derived, it must be saturated steam; while superheated steam (apart from (2)) is steam heated to a higher temperature after all the water from which it was derived has been evaporated, or is no longer in contact with it.

Steam may be used either as *current* or *confined* steam. Current steam is a stream of steam. There is a constant circulation going on. Confined steam is steam boxed up in a chamber, the inlet and outlet of which are closed after it has been filled with steam and all the air expelled. Current steam has a much greater penetrating power than confined steam. Steam may be used either at ordinary atmospheric pressure or at higher pressure. The term "without pressure" means at ordinary atmospheric pressure; "at low pressure" means pressure varying from 15 to 25 lb. per square inch; "at high pressure" means pressures of 25 lb. and over.

The temperature obtained for disinfection, using steam without pressure, is 100° C. At low pressure a temperature of 100° C. to 110° C. is forthcoming; while with high pressure a temperature of 110° C. to 120° C. is reached. Steam at the higher pressures penetrates more thoroughly and more rapidly, and disinfects more quickly than at atmospheric and low pressures. Twenty minutes of the former is equivalent to an hour of the latter as regards time. The apparatus required varies with the conditions under which the steam is to be used; but whatever the apparatus be, efficiency requires that—(1) during disinfection a constant temperature must be maintained at the maximum required; (2) the heat must be uniformly and rapidly distributed, and the steam must be free from air; (3) the apparatus should itself record the temperature and pressure; (4) the contents should not be over-wetted, and should be partially dried after disinfection.

In addition, the apparatus should be comparatively cheap as regards original cost, up-keep, and working, and should be as simple in design as possible and easy to manage. There is a large variety of steam disinfectors, of which the following constitute distinct types:—

Washington-Lyon.—This consists of an oval chamber with a double wall or jacket. Steam from a boiler can be admitted into both chamber and jacket, while each cavity has its own manometer and safety valve. The articles to be disinfected are hung on hooks inside the chamber, or arranged on a cage or trolley which runs on rails. The doors are then securely closed and clamped. Steam is first passed into the jacket under a pressure of 20 to 30 lb., with the object of heating the air, wall, and contents of the chamber, so that when steam is admitted into it little condensation will take place. In some cases there is an arrangement for exhausting the air from the inner chamber prior to the admission of steam. This greatly aids the penetrating power of the disinfecting steam. Steam under a pressure of not more than 20 lb. is then admitted to the closed chamber, and since steam at a higher pressure is still maintained in the jacket, the steam in the chamber is superheated.

One advantage of this is that the articles are not over-wetted. This superheated steam is kept in contact with the articles for from twenty minutes to an hour, the time varying with the bulk and nature of the materials requiring disinfection. When the process is complete, the steam in the chamber is shut off, while that in the jacket remains, and thus converts the chamber into a drying cell. To facilitate this action, hot air is drawn through the chamber, and when the contents are fairly dry, steam is cut off from the outer jacket, and they are removed through the opposite door to that by which they were inserted. There are pipes by which any condensed steam can be let off. It is useful during the process to every now and then shut off steam and turn on the air exhaust, so as to aid the steam in its effort at penetration. The Washington-Lyon apparatus can be also utilised for disinfection with saturated steam by maintaining the steam at the same pressure both in the jacket and the chamber.

The Equifex.—In this apparatus confined saturated steam is employed in an iron chamber which has no jacket, but is so covered as to reduce the loss of heat. The arrangements for the insertion and removal of articles are somewhat similar to those described above. Coiled steam-pipes are arranged inside the chamber, and contain high pressure steam, thus preventing condensation and heating the air, which is used for drying purposes subsequent to the disinfection. Steam is passed into the chamber, the air driven out, and a pressure of 10 lb. maintained. A temperature of about 115° to 120° C. is forthcoming in five minutes, and is employed for twenty minutes. Here also the air exhaust is of value, and one type of this disinfector is devised for use with steam under low pressure.

Thresh's disinfector is adapted for the use of superheated steam obtained from water impregnated with calcium chloride. There is a chamber with a jacket which forms the boiler, contains the saline fluid, and is heated by a subjacent furnace. The steam from this fluid comes off at a temperature slightly above 100° C., and is used as current steam without pressure. Disinfection takes about half an hour, the steam is then cut off, and air is aspirated through for drying purposes, the air being heated by being carried along a pipe which passes through the hot saline liquid. There is an automatic arrangement for keeping the solution at a constant strength by the admission of water, as otherwise deposit would take place from the concentrated liquid. In any case this is apt to occur, and from the construction of the apparatus cleansing is not easy.

Reck's disinfector is a low pressure apparatus devoid of a jacket, and possessing a cold water douche which frees the cylindrical chamber from steam after disinfection, the articles being protected from wet by a metal arch. The current steam is at a pressure of $1\frac{1}{2}$ lb., and the process takes one hour. The drawback in all low pressure apparatus is the low penetrating power of the steam, the air not being sufficiently driven out by the entering steam, nor fully extracted by the air exhaust from the interstices of the articles under disinfection. Probably the best results from low pressure machines are obtained when the steam is used in current form. As in boiling, all stained fabrics should be steeped in cold water, and, if necessary, washed prior to insertion in the disinfecting chamber. This can be effected by an automatic apparatus, thus obviating any danger of spread of infection. As before, the water used for washing should afterwards be sterilised by boiling.

Examination of Disinfectants, and of the Efficiency of Steam Disinfectors.—The only certain test both for disinfectants and disinfectors is their effect upon the most resistant micro-organism known, namely, the spores of anthrax. This may be termed the biological test, and, in a minor degree, similar tests may be carried out by adding disinfectants to culture, media which are then inoculated with such organisms as staphylococci, *B. coli communis*, etc. In addition, chemical disinfectants may be examined chemically, and gaseous disinfectants and steam apparatus physically. Strips of linen smeared with material containing anthrax spores are, in the biological test, exposed to the action of the disinfectant for varying periods, and the viability of these spores is thereafter tested both in culture and by injection into animals. Similarly prepared strips are placed in the interior of the disinfector under trial, being covered by layers of more or less easily penetrated fabric, and the time taken by the hot air, or the steam, to kill the spores is duly noted.

The purity of carbolic acid, as regards the amount of inert tar oil it contains, can be tested by shaking a measured volume of the acid with twice its volume of pure soda solution of a strength of 9 per cent. The soda dissolves the cresylic and carbolic acids, the oils separating out, the heavy sinking, and the light rising. Their respective volumes can thus be ascertained.

The available chlorine must be determined in bleaching powder. This is done by means of a standard solution of arsenite of soda, of which 1 c.c. = 3·55 mgrms. Cl. The test is applied by mixing 10 grms. of bleaching powder with a little water, diluting to 1 litre, and titrating 10 c.c. of the solution with the arsenite, adding the latter until the bleaching powder has lost its power of striking blue with iodide of starch paper. As long as there is any available chlorine left in the bleaching powder solution, oxygen will be set free, and this will continue to convert the arsenite into arseniate. The amount of oxygen thus utilised is directly proportional to the chlorine available, and so from the amount of arsenite used the available chlorine is determined. It is expressed as a percentage of the bleaching powder.

The time required to attain a certain temperature in disinfecting chambers may be tested by means of a contact thermometer, which may be placed deep in the folds of blankets or in a mattress, and when the required temperature is reached in this situation, the mercury in the thermometer completes an electric circuit which results in the ringing of a bell. A maximum thermometer inserted in the chamber of a disinfector will show the temperature which has been attained during disinfection.

Provisions for Disinfection.—Large towns require a complete outfit for battling with infectious disease. The expense thus incurred is more than repaid by the arrest of epidemics. A steam disinfecting station should be established, and should contain two apartments completely separated by a wall in which there is neither door nor window, but through which, or into which, the disinfector is built, so that its door of entry is in one room, and its door of exit in another. Thus one room is entirely reserved for infected articles, and the other receives them after disinfection, so that there is no risk of re-contamination. The floor and walls of both apartments should be smooth and impervious, a plentiful supply of water should be laid on, and ventilation and lighting should be as perfect as possible. Provision should also be made of means whereby articles may, if necessary, be destroyed by fire. The establishment, as in Glasgow, of public wash-houses is to be highly commended. At such places, infected linen, etc., which, very properly, private laundries will not receive, can be dealt with ; ordinary laundry expenses being charged. Separate vans should be employed for bringing infected articles, and for returning them after disinfection, and they should be kept in separate sheds. It is convenient to have the disinfecting station at the infectious diseases hospital for obvious reasons, and the hospital laundry is then available for cleansing disinfected articles before return. At the disinfecting station there should be kept overalls or special suits and goggles for those undertaking the work of disinfection, and, in addition, spray apparatus, tools, brushes, etc., must be provided. In country districts, where villages are scattered, a portable disinfector is convenient. There are several varieties of these. In the South African hospital camps Thresh's machine was employed, and a form of the Equifex is also adapted for such work.

Practical Application of Disinfection.—Patient, properties, and premises have all to be disinfected. The disinfection of the patient includes that of himself, his discharges and excreta, and as applied to cutaneous surfaces and mucous membranes, as well as to the last named, has been described under the diseases themselves (*vide* Medicine). Fomites removed from infected premises to a disinfecting station should be conveyed in large canvas bags slightly moistened on the outside to prevent the dissemination of bacteria. These bags should be carefully labelled to prevent confusion. Their contents are best disinfected by steam, any articles which are stained being first of all soaked or washed as described. If steam is not available, they should be boiled wherever possible, as in the case of underclothing and bed linen. Blankets may be disinfected by steeping them for twenty minutes in 2 per cent. formalin. Articles of little value should be burned. Boots and leather goods may be swabbed with 2 per cent. formalin, and books exposed, with their leaves opened out, to the vapour of formalin in a closed chamber. Picture frames, wood and metal substances, glass and crockery, are to be rubbed with 2 per cent. carbolic acid solution.

Premises.—As regards a room, ward, lobby, etc., the means at our disposal are—

1. Fumigation.—This, as usually conducted, is not satisfactory, and cannot be relied upon. A very little dust will shelter microbes from the most powerful disinfectant vapours, and the process must always be supplemented by thorough cleansing and aeration with the admission of sunlight. Before fumigating, anything which is likely to suffer from the chemical nature of the disinfectant must be removed, the walls should be bared, and all hangings taken down. Every outlet, including the chimney, must be closed.

(*a*) *Formic aldehyde.*—If a Trillat's autoclave be employed, the long copper tube is passed into the room through the keyhole. Disinfection is continued for at least six hours. If the hydroformant lamp is used, 5 grms. of paraform are necessary for every 100 cubic ft. Care must be taken in entering the room when the process is completed. The eyes should be protected by goggles, while the mouth can be covered with a damp cloth. Ammonia has the power of relieving the ill effects of the gas, and dispelling the vapours.

(*b*) *Chlorine.*—The bleaching powder is placed about the room in small vessels, which should be at a high level to ensure diffusion, as the gas is heavy. The acid is poured on the powder, the mouth of the operator being protected by a cloth wetted with weak ammonia solution. 1 to 2 lb. of the powder with half its weight of acid is sufficient for 1000 cubic ft. if the air be moist. It must be remembered that metal fittings should be removed before the chlorine is generated. The gas should be left in the room for several hours.

(*c*) *Sulphurous acid.*—In addition to what has been said regarding this disinfectant (p. 271), the risk of fire is to be avoided by placing the vessel, with the sulphur or the sulphur candle, on a tray containing sand over a pail of water. Sulphur acts specially on brass work, bronze, copper, and the gilt frames of pictures. Silver ware, bound books, and leather articles should also be removed. As in the case of chlorine, the air and wall surface should first of all be rendered moist, and the gas liberated as near the ceiling as possible. At the end of the fumigation the room can be entered if a cloth wetted with solution of carbonate of soda be kept over the face and mouth. Sulphur disinfection is continued for from six to twenty-four hours, it being customary to devote a night to the operation. There should be no difficulty in inventing some method of opening the windows from the outside after fumigation, thus doing away with the necessity of entering the room until it has been well aired.

2. Spraying.—This is done by means of special manual pumps which discharge a very finely divided spray, the drops of which adhere to the surface upon which they strike and even penetrate it slightly. Carbolic acid (1 in 200), formalin, chinosol (1 in 600), lysol, and sodium hypochlorite (1 in 100) may all be used. Corrosive sublimate (1 in 1000) is recommended, but its action on metals renders it unsuitable for use in most spray apparatus. Leslie Mackenzie, a strong advocate of this method, used to employ a solution containing 4 oz. of formalin and 5 oz. of glycerine in 1 gallon of water. He recommends a special pump which has the advantage that it can be kept steady by the foot and worked with one hand, while the other directs the nozzle. The tube to which the nozzle is fitted can be extended if necessary, so that the latter can always be closely approximated to the surface to be sprayed. The pump is light, portable, cheap, can be worked by one man, and contains no reservoir, any bucket being used to hold the disinfectant. Such a spray should have a double action pump, and therefore a constant discharge.

If formalin be used, some of the formic aldehyde is also produced in the form of a gas, while chlorine is liberated in the case of sodium hypochlorite. It takes about an hour to thoroughly spray a small room, and special attention should be paid to the corners, cornice crevices, and other lurking-places of dust and bacteria. Unless precautions are taken, the operator may suffer inconvenience, especially when spraying with formalin or sodium hypochlorite.

3. Washing and Scrubbing.—As a preliminary, the walls may be rubbed down with stale bread, beginning at the ceiling angles. The crumbs are to be collected and burned. Then, where possible, the skirting boards are to be removed, and sometimes even the floor boards raised, the ceiling, walls, floor,

and furniture are to be washed with soap and water, and then with 5 per cent. carbolic acid solution, or chloride of lime 1 per cent. If the walls are papered, the papers should previously have been wholly stripped off if they are of the unwashable, non-hygienic variety. This elaborate procedure is then concluded by the free admission of air and light, while all débris must be burned, and the brushes, etc., used in the operation, as well as the clothes or overalls of the operators, have to be disinfected. Somewhat similar methods are applicable to conveyances and railway carriages. Stables and cowsheds may require specially thorough disinfection owing to the presence of anthrax. Whatever can be burned should be burned, provided little monetary loss is entailed; the surface mortar should be picked out from between the stones and added to the fire, and the paving stones themselves should be subjected to intense heat. Limewashing, tarring, and painting are all useful aids. The general rules for disinfection apply also to ships; the rats, but not the cargo, being disturbed during fumigation. Hulks containing apparatus for the generation of sulphur dioxide gas or chlorine, and tubes along which the gas can be pumped into the hold, are in common use. In addition, the bilge is best treated by the addition of milk of lime till it is strongly alkaline, or it may be pumped out of the ship. After cholera and enteric fever outbreaks, water pipes can be disinfected by filling them with 2 per cent. carbolic acid for twenty-four hours, and then flushing with pure water. Drain pipes are best cleansed by a solution of ferrous sulphate, 1 lb. to the gallon of water, corrosive sublimate and chloride of lime being inadmissible, while sewers can be treated by a solution of chloros or by Reevozone, a special gaseous process, after which they are flushed. Sewage farms which have become contaminated with the vibrios of cholera and with enteric excreta, can be freed from danger by the liberal addition of milk of lime to the tanks and carriers.

TABLE SHOWING THE THERMAL DEATH-POINT OF THE MORE IMPORTANT PATHOGENETIC BACTERIA.

Organism.	Thermal Death-point.	
	Moist Heat in degrees C.	Period of Exposure advisable.
B. anthracis organism	65°	10 minutes.
B. anthracis spores	120°	1 hour.
V. choleræ	65°	10 minutes.
B. diphtheriæ	65°	10 ,,
S. erysipelatis	65°	10 ,,
B. influenzæ	65°	10 ,,
B. pestis	65°	10 ,,
S. Obermeieri	65°	10 ,,
B. tetani organism	80°	15 ,,
B. tetani spores	110°	30 ,,
B. tuberculosis	70°	1 hour.
B. typhosus	65°	30 minutes.
	100°	2 to 3 ,,

DEODORANTS.

The most powerful deodorant is nitrogen tetroxide, as is shown by the efficiency with which it removes the persistent smell that hangs about mortuaries. As already pointed out, most of the disinfectants are also deodorisers, by virtue of their oxidising or reducing actions. Slaked lime absorbs sulphuretted hydrogen and organic vapours, and potassium permanganate is useful, Condy's fluid being an alkaline permanganate. Various carbolic powders, turpentine, camphoraceous essences, "sanitas" (peroxide of hydrogen, camphor, and camphoric acid), and charcoal, notably vegetable charcoal, are all deodorants, but one of the simplest and best is that which has deodorised the great majority of the human race, namely, dry earth.

QUARANTINE.

Quarantine, derived from the French *quarante*, forty, originally meant the forty days' detention to which ships and those aboard them were subjected on "coming foreign" either infected or suspected to carry infection. As now used, the term denotes the segregation or precautionary isolation of any who have been exposed to infection, and who may thus serve as centres of infection, and is extended to apply, not only to ships, but to all conditions under which the community is exposed to the risk of contracting infectious disorder. Indeed, as applied in this country to ships, quarantine regulations have been so modified and restricted that the old term is now but rarely used in its whilom nautical sense, and is most commonly employed in connection with municipal sanitary work. In such work quarantine may be upon a varying scale. Thus "quarantine of contacts" may be enforced, as in typhus fever, smallpox, and plague, the sanitary authorities providing houses of reception, often adjacent to the isolation hospital, for those who have been in contact with cases of infectious disease. Such persons are kept under observation for a period slightly longer than the maximum period of incubation of the disease to the infection of which they have been exposed. The sanitary authority may in this case feed, as well as house, such persons, and pay the wages of those who, though not ill, are detained from work. In a milder form quarantine imposes restrictions on those constituting the household of the person affected, by keeping them strictly confined to the house, prohibiting outside intercourse and the carrying on of such employment as may infect fomites or food, *i.e.* tailoring, washing, mangling, milk-vending, baking, etc.

This form of quarantine must be maintained until the last case in the house has ceased to be infectious, and thorough disinfection has been carried out.

Vaccination and re-vaccination are valuable aids in reducing the period of quarantine necessary in the case of smallpox.

In addition to the seclusion, disinfection both of "contacts" and their clothes and belongings is in all cases essential. Further, when "contacts" have been removed to a quarantine station, their homes must be thoroughly disinfected and cleaned before they are allowed to return to them.

To a certain extent quarantine is still practised at British ports in the case of ships "coming foreign," as provided for in the Cholera, Yellow Fever, and Plague Regulations (p. 537). In some other countries a more prolonged quarantine is still in force.

ISOLATION.

This important question has to some extent been already discussed in connection with the communicable diseases. Isolation not only gives the patient a better chance of combating the disease, but especially benefits the community by depriving the infective virus of its opportunities for sustenance and spread in and amongst susceptible persons. Isolation does not necessarily mean solitude. It provides for the segregation of cases of the same disease, in order to protect from that disease those in health and those suffering from other communicable complaints. It may be carried out in the house of the patient, or in an infectious diseases or special hospital. In "home" isolation the patient should, where possible, be placed in a room at the top of the house, or at a distance from other apartments, and a sheet, wrung out of a disinfectant solution, may with advantage be hung outside the closed door of the room, more for the purpose of acting as a warning than for any disinfectant action. A fire should be kept burning, both for purposes of ventilation and to provide a ready means for the incineration of rags, etc. Hospital isolation is much to be preferred, especially for the poorer classes, and in certain of the communicable diseases. On account of their infectivity, their great tendency to spread, and the fact that they claim as victims persons at all periods of life, such diseases as smallpox, plague, and yellow fever are best treated in special hospitals reserved for them alone. The same is true of cholera, because it is essential to control the disposal of cholera dejecta, and therefore to have the patients under constant supervision. Cases of dysentery, enteric fever, erysipelas, diphtheria, typhus fever, relapsing fever, scarlet fever, measles, rubeola, fourth disease, chickenpox, and whooping-cough may be treated in the ordinary infectious diseases hospital. Leprosy is best dealt with by special segregation in a leper colony. As regards tubercle, at least phthisis, isolation in a special hospital is very desirable in advanced stages of the disease, for the benefit of the community rather than of the sufferer. "Home" isolation suffices for influenza, mumps, and puerperal fever, such diseases not being usually admitted to an infectious diseases hospital. Severe forms of venereal disease are provided for by lock hospitals, and in the tropics somewhat similar arrangements obtain for yaws.

Modified forms of isolation are now available for tuberculosis and malaria. To be efficient, isolation must be begun early, continued without interruption, and maintained until the patient is no longer capable of transmitting the disease.

Disadvantages of Hospital Isolation.—These are—

1. The danger of increasing the severity of the disease by grouping a number of cases together, especially if mild and severe cases be treated in one ward.

2. The chance of "cross infection," as when a patient admitted with scarlet fever contracts diphtheria.

Both risks are greatly minimised by proper hospital construction and common-sense precautions.

NOTIFICATION.

Notification is considered under the sections of Medicine and Law.

It is to be borne in mind that, uncombined with other measures, notification is of no value in combating communicable disease. The intelligence obtained must be acted upon. When, however, it is to be followed by isolation and disinfection, it is of value in—

1. Giving a clue to the source of disease. Thus it frequently groups the cases in such a way that one is enabled to say, "Here we are dealing with a milk-, or it may be a water-, borne epidemic." In addition, it singles out the primary cases which lie nearest the root of the mischief.
2. Drawing early attention to the presence of disease which may become epidemic.
3. Inculcating watchfulness upon the general practitioner, and suggesting the need for a definite diagnosis in doubtful cases.
4. Collecting information as to the total prevalence of infectious disease in the district and its distribution.
5. Facilitating due enforcement of the provisions of the Public Health Act.
6. Permitting the offer of removal to hospital, and in certain cases the compulsory removal.
7. Directing attention to the sanitary condition of invaded dwellings.
8. Showing at once what households require to be quarantined.

Its great disadvantage is its expense, but this is more than balanced by the advantages accruing from it. The diseases in which notification is most useful are those in which the danger of transmission is not great before the symptoms have sufficiently developed to enable a definite diagnosis to be made. A typical example is scarlet fever, whilst the converse is well exemplified by measles.

PREVENTIVE INOCULATION.

Still following out our consideration of the means at our disposal for defeating the aim and object of the virus or ever it obtains a lodgment in the tissues, we reach the subject of preventive inoculation.

Such inoculations may consist of—(1) the injection of the living virus in an attenuated form followed by its introduction in a state of exalted virulence; (2) the injection of the virus after it has been killed; (3) the injection of products of cultivation of the virus.

These three methods may be employed directly on the human being, or they may first of all be applied to certain of the lower animals, and the blood serum of those animals thereafter utilised for the injection.

Let us now briefly consider the procedure adopted in the case of the five diseases which at the present time are guarded against by preventive inoculation.

Cholera.—In this instance the living virus is used, at first much attenuated, and later in a more virulent form (Haffkine).

Diphtheria.—Here the serum of a horse, immunised by the repeated injection of Löffler's bacillus or of its cultures, is employed. This is the same serum as is used for curative purposes, and now also recommended as a preventative (Netter).

Enteric Fever.—The dead bacilli together with the product of their previous growth in broth culture are utilised (Wright).

Plague.—Injection of dead cultures of *Bacillus pestis* may be practised

(Haffkine), or the serum of a horse, immunised by repeated inoculations with *B. pestis*, may be used (Yersin). Lustig and Galeotti have prepared a serum from horses which is bactericidal. The horse is injected with a nucleo-proteid isolated from plague microbes.

Smallpox.—As the specific organism of smallpox has not yet been isolated, we are to a certain extent still in the dark as regards our knowledge of the precise nature, though not of the value, of vaccination.

If cowpox is smallpox in the cow, then vaccination is a means of prevention by inoculating with a virus attenuated by passage through an animal. If cowpox is not smallpox in the cow, then the protection is afforded by the inoculation of the virus of a disease closely allied to smallpox. During the latter half of the eighteenth century and the early years of the nineteenth century, inoculation of smallpox was practised, but this was finally rendered illegal in 1840. Inoculation did not increase the prevalence of smallpox, since in those days nearly every one had smallpox at some time or other in their lives, but the inoculated form was of a milder type. The disadvantages of inoculated smallpox were that it was a general illness, and not a merely local disease at the seat of inoculation, and that it was communicable from person to person. Its advantage was that it conferred a certain immunity from a severe, and possibly fatal, attack of smallpox.

VACCINATION.

The practice of vaccination had its origin in Jenner's observation that an attack of cowpox served to protect from smallpox, and that the inoculation of cowpox gave rise to a local disease, which was not communicable to others except by inoculation. By inoculation from child to child, or arm-to-arm vaccination, the protective disease was induced in successive generations. This requires great care in the selection of vaccinifers, *i.e.* vaccination should only be performed from the arms of thoroughly healthy children, so as to avoid any risk of the transmission of other diseases as well as vaccinia. The actual risk of such transmission by the lymph is no doubt slight, but it exists, and therefore the practice of using only calf lymph is being substituted. In this method, vaccinia is kept up by inoculation into successive generations of calves, and each child is inoculated with lymph direct from the calf. It was found that calf lymph was apt to contain certain organisms in addition to the vaccinal virus, and that these occasionally gave rise to inflammatory conditions. In order to obviate this, the calf lymph is now mixed with glycerine, which is found to inhibit the growth of such organisms, while permitting the virus to produce vaccinia. Vaccination is now performed largely with glycerinated calf lymph. The statistics with regard to vaccination in the past relate mainly to the period when arm-to-arm vaccination was in vogue; those now being accumulated will show us the effect of calf lymph and glycerinated calf lymph. Vaccination came gradually into use in the early years of the nineteenth century, and was gratuitously provided after 1840, though it remained optional till 1853. In the period 1854–71 it was obligatory, but not thoroughly enforced; but from 1872–98 the obligation was very generally complied with. In 1898 the regulations were further altered so as to allow exemption of those children whose parents satisfied a magistrate of their "conscientious objection" to vaccination. The Royal Commission on Vaccination, which reported in 1896, came to definite conclusions as to its advantages, and the following is an epitome of these conclusions :—

(*a*) Vaccination lessens the liability to attack of smallpox, and in the event of attack renders the disease less fatal, and of a milder type.

(*b*) Vaccination protects from smallpox for a variable number of years, usually nine to ten years, and still notably protects for the next five years, but usually confers a lesser protection in later years, although the immunity may continue for the whole of life.

(*c*) Vaccination modifies a subsequent attack of smallpox, most markedly in the early years after its performance, but this influence does not diminish so rapidly as its protective action, and is powerful even after many years.

(*d*) Re-vaccination restores the protection for a certain number of years, and as the protection again lessens, repetition of re-vaccination may become advisable.

(*e*) The quality of vaccination influences its results. The most thorough vaccination is by far the most effective in protection from smallpox, and in modification of the disease. Three or four marks are distinctly better than one or two, and the cicatricial area should not be less than half a square inch.

Few people are really insusceptible to vaccination unless they have passed through an attack of smallpox, or been recently successfully vaccinated. Every child should be vaccinated, and must have the process performed, unless its parents are certified by a magistrate as having a conscientious belief that vaccination would be prejudicial to the health of the child! The medical man is permitted to postpone vaccination for two months, if he sees fit, either on account of the ill-health of the child, or of attendant circumstances, such as prevalence of other infectious diseases than smallpox, insanitary surroundings, etc. When vaccination has been performed successfully, the doctor must certify to that effect : and when unsuccessfully, he may give a certificate of insusceptibility to the infection. A certificate of insusceptibility should not be given unless vaccination has been performed three times without result. The percentage of insusceptible cases is much higher in the practice of private practitioners than in that of public vaccinators. Re-vaccination is advisable after ten years, and is compulsory in Germany during the twelfth year of age ; and re-vaccination should be repeated in later life, more especially if there be any imminent risk of infection by smallpox. Re-vaccination should only be regarded as successful if vesicles or papules, surrounded by areolæ, are formed. Imperfect vaccination only partially protects against smallpox, or repeated vaccination ; and if, on original vaccination, an imperfect vesiculation is obtained, the child will react partially to a further vaccination. Auto-inoculation is possible up to the end of the first week ; and Cory found that a child vaccinated every day for eleven days reacted up to the ninth day, and not thereafter.

The chief objections urged against vaccination are—

1. That it does not protect against smallpox. This is not true, but it is the case that its power of protection is not permanent. Thorough vaccination absolutely protects, and the discredit thrown upon the process has its basis in imperfect vaccination. Apart from the protective action, vaccination powerfully modifies subsequent smallpox, and would be valuable even if it did not protect.

2. Transmission of other diseases besides vaccinia, the most important being syphilis, leprosy, and erysipelas. Syphilis has been transmitted by

vaccination in the days of arm-to-arm vaccination, but very few cases are known to have occurred in this country. The introduction of calf lymph and strict aseptic precautions have banished this danger, and also that of leprosy in those countries where the latter is prevalent. The argument that the undoubted increase in infant deaths from syphilis is due to more general vaccination, may be refuted by the fact that such deaths largely occur in the first few weeks of life, and before the period of vaccination. The risk of erysipelas is practically obviated by protecting the vaccinated area from any chance of infection, by the use of good lymph and clean instruments. There is no evidence that other diseases, such as tuberculosis, can be handed on by vaccination.

3. That it is unnecessary, equally good results being obtained by isolation. Isolation implies attendance, and if this were performed by unvaccinated persons, isolation would not give equally good results. This is proved by the experience of the nurses and attendants at the Metropolitan Asylums Board Hospitals, where all the staff who had not had smallpox, or had not been re-vaccinated, took the disease. As a matter of fact, the isolated patient is surrounded by a cordon of vaccinated persons, and it is impossible to separate pure isolation statistics from pure vaccination statistics, the practice of vaccination being so general. Isolation, to be efficient by itself, would demand not only segregation of patients, but also quarantine of all contacts, and this entails loss of working time, compensation, and a much greater interference with individual liberty than does vaccination.

SCHOOL HYGIENE.

Under this heading are included considerations affecting the scholar, the building in which he is educated, and the regimen to which he is subjected. The construction and arrangement of schools is discussed elsewhere (p. 412); here we deal briefly with the scholar and the conditions under which he labours. Children attending school are liable to the maladies incidental to their age, and also to special diseases, often the fault of non-hygienic surroundings, etc. Thus, working in defective light, the use of small print, badly arranged desks, and long hours of work, are apt to cause myopia. Various deformities, such as spinal curvature, may be due to ill-constructed desks and seats, and the resultant cramped and faulty positions assumed. Neurasthenia and the arrest of healthy growth may be induced by too long or too concentrated study without periods of relaxation, indulgence in exercise, and sufficient food. Deficient ventilation may predispose towards tubercle and the spread of other communicable diseases, and is largely accountable for the purulent ophthalmia so prevalent and persistent in school children. Want of cleanliness of the clothes and person favours parasitic affections of various kinds. Diphtheria is par excellence the dangerous infectious disease of school life. Its chief incidence is on children at school ages, and their customs tend to favour its spread, as does their aggregation in rooms which are at all deficient in light and ventilation. The intimate association engendered by school life, and the delight in mimicry, so characteristic of children, conduces to the formation of bad habits and the acquisition of so-called "imitative" diseases, such as chorea.

From what has been said, it will be apparent that the remedy for such conditions, apart from proper training, the inculcation of cleanly habits, the regulation of hours of work and play, and the adaptation of the task to the scholar, and not of the scholar to the task, lies chiefly in the careful construction of the schoolroom, and the provision of hygienic school premises, such as are described in due course.

Schools and Infectious Disease.—The occurrence of infectious disease in schools frequently gives rise to the consideration of such measures as school closure, or the exclusion of particular scholars, with a view to prevent the spread of infection. The medical officer of health, or the medical attendant of the school, should endeavour to attain this object with as little interruption as possible to the ordinary work of the school. It is a condition of the annual parliamentary grant to public elementary schools, imposed by the Code of Regulations, approved by the Lords of the Committee of Council on Education (art. 98), "That the managers must at once comply with any notice of the sanitary authority of the district in which the school is situated, requiring them for a specified time, with a view to preventing the spread of disease, either to close the school or to exclude any scholars from attendance, but, after complying, they may appeal to the Department, if they consider the notice to be unreasonable." School closure, or the exclusion of particular scholars, is most often required for the following diseases:—Scarlet fever, measles, diphtheria, whooping-cough, smallpox, and rubeola, and more or less in the order of frequency shown in this list; less often for enteric fever or diarrhœal diseases, owing to infected school privies or other local conditions.

Exclusion of Particular Scholars.—All children suffering from any dangerous infectious disease should be excluded from school till they have ceased to be infectious. In the case of public elementary schools, it is usually necessary to exclude all children coming from the infected house, or sometimes even street or hamlet, owing to danger of spread of the disease in a latent or unrecognised form, or by means of fomites. As a rule, the same measure should be enforced in the case of infectious disease which is not dangerous, *e.g.* ringworm, chickenpox, mumps, etc.

School Closure.—This should only be enforced when there is a clear prospect of preventing the propagation of epidemic disease by so doing. The chief proofs showing that the disease is being spread at school, are—(*a*) in the majority of households attacked, the first case is that of a child attending the school; (*b*) a number of children are simultaneously attacked, whose only circumstance in common is the attendance at school, their residences being often far apart; (*c*) a child, or teacher, in an infectious state, is known to have been attending the school.

The medical officer of health, on becoming aware of the existence of dangerous infectious disease in his district, should give notice at once to the teachers of the school or schools at which children from infected households may be attending, and should request the exclusion of such children for a period specified by him. At the close of such period, it is advisable for the medical officer of health to intimate to the teacher that danger is at an end, and also to similarly notify the School Board. School Board officers and schoolmasters, becoming aware of the existence of suspected infectious disease amongst scholars, should notify the medical officer of health; and if several children from the same household are absentees from school, the medical officer of health should likewise be notified, no matter what name be given to the complaint. Schoolmasters should be invited to notify the medical officer of health if they notice children suffering from what may be the initial symptoms of infectious disease during times of epidemic prevalence, such as of scarlet fever, measles, and diphtheria. Such children are best excluded from school. The medical officer of health should be the arbiter as to the duration of the exclusion of scholars, and, in specifying the time, he should consider the nature of the infection, the length of the illness, and the environment of the patient, in so far as these may influence the spread of the infection to others. The medical officer of health should make inquiry towards the end of the exclusion period, and prolong it if necessary, giving fresh notice to the school authorities. The decision between school closure or exclusion of particular scholars in any case demands consideration of the following points:—

1. "The completeness and promptness of the information received by the officers of the sanitary authority respecting the occurrence of infectious cases.

2. "The opportunities which exist for intercourse between the children of different households elsewhere than at school."

Where cases are few, recognised early, and their origin known, exclusion is likely to suffice; but where the centres of infection are numerous, and many cases are likely to be undiscovered or unrecognised, school closure is more often necessary. If measures of exclusion fail to stay an epidemic among school children, it is probable that mild cases are occurring among those still in attendance, and school closure may become necessary. Where a large proportion of the scholars are absent ill, it may be well to close the school, for example, during a measles epidemic. In towns, school closure is less likely to effect the separation of the scholars than in rural districts, where the homes of schoolfellows are often far apart. School closure for a limited period may be necessary to allow of the rectification of sanitary defects on the premises, or in case of infectious disease in the family of a resident schoolmaster. In exceptional cases, it may be necessary to close more than one school in the same place during the same epidemic, in order to prevent scholars, shut out from one school, attending another.

Schools, with the exception of Sunday schools and other private schools, may be closed under the Education Code mentioned above; but the closure of Sunday schools and private schools may be enforced if these contravene ss. 21 and 126 of the Public Health Act, 1875. As a rule, the managers of such schools are willing to accede to representations and requests by the sanitary authorities.

In Scotland, the Public Health Act, 1897, imposes a penalty on any person sending a child to school so as to spread infection, and further, on any teacher or person in charge of a school who allows a child, liable to spread infection, to attend school. Closure of schools is provided for under the Scottish Education Code, 1897, art. 30.

The medical officer of health or local authority must send to the Local Government Board a copy of any report the medical officer of health may make to the local authority advising closure of schools, and the medical officer of health must state his reasons for preferring closure to the exclusion of particular scholars. The local authority must give written notice to the managers of a public elementary school when the closure of a school is required, and must state the grounds on which it is deemed necessary. The notice should specify the time during which the school must be closed, should not specify a longer time than is absolutely essential, and may be followed by a second notice if the reopening of the school must be postponed. These are the recommendations contained in a memorandum issued by the Local Government Board in 1890 with regard to schools and infectious diseases.

The following precautions against the introduction of communicable disease to boarding-schools, and against its outbreak and spread in them, are usually taken. Each child on returning to school must bring a health certificate, signed by its parent or guardian not earlier than one day prior to the opening of the school-term, stating that during the three previous weeks the child has not been exposed to any infectious disorder.

On the first admission of a child to the school, a statement is required showing those infectious and other diseases, if any, from which the child has suffered. This is preserved, and is a valuable help to the medical officer of the school in estimating the number of children liable to attack by any particular disease. No child should be allowed to return to school after infectious illness without having been thoroughly disinfected, and without a medical certificate of freedom from infection. Each school is usually provided with an isolation room or block, according to its size, and, if large, should possess a disinfecting apparatus. Unvaccinated children, or those with imperfect vaccination marks, should be vaccinated or re-vaccinated unless they happen to have had smallpox. Re-vaccination is advisable for all children above 12 years of age who have not been re-vaccinated since infancy.

Duration of Exclusion.—The duration of exclusion from school varies in different diseases, and cannot always be stated as a definite period. Such diseases as ophthalmia, scabies, and ringworm may have a prolonged course, and until all traces have vanished, the child must remain away from school. In ringworm of the scalp the growth of new hair is no evidence of the absence of the disease, as long as there still remain broken hairs. The application of chloroform to a suspected spot causes any infected hairs to assume a white "hoar frost" appearance. The following table is modified from that approved by the Association of Medical Officers of Schools as regards quarantine and return to school :—

Disease.	Quarantine required after last Exposure to Infection.	Earliest Date of Return to School after an Attack.
Diphtheria	Twelve days.	Three weeks if convalescence complete.
Enteric fever	Three weeks.	Eight weeks if convalescence complete.
"Fourth disease"	Sixteen days.	Three weeks if convalescence complete.
Measles	Sixteen days.	Three weeks if convalescence complete, and desquamation has ceased.
Mumps	Twenty-four days.	Four weeks if all swelling gone.
Rubeola	Sixteen days.	Three weeks if convalescence complete.
Scarlet fever	Eight days.	Six to eight weeks if convalescence complete, and desquamation has ceased.
Typhus fever	Seventeen days.	Six weeks if convalescence complete.
Varicella	Eighteen days.	When all the scabs have fallen off.
Variola	Eighteen days.	Two weeks after all the scabs have fallen off.
Whooping-cough	Twenty-one days.	Six weeks from commencement of the whooping if characteristic cough and whooping have ceased. Earlier if all cough be gone.

DISPOSAL OF DEAD.

The methods of disposal of the dead have varied at different periods of the world's history, according to racial custom, religion, climate, convenience, etc. These factors still influence the habits of various peoples in this respect. The following are the means employed :—(1) Earth burial ; (2) cremation ; (3) vault burial ; (4) cave burial, as in Syria ; (5) exposure to the air with a view to desiccation and mummification (Australian aborigines) ; (6) sea and river burial (India) ; (7) anthropophagy, as practised by cannibal races, and by those peoples who yield their dead to the beasts of the field and the birds of the air (Parsees and certain tribes of American Indians) ; (8) embalming.

In this country the only two modes in common vogue since vault burial was restricted, are earth burial and cremation.

Earth Burial.—*Cemeteries.*—The site of a town or city cemetery is a matter of importance to the community. New burial grounds should be confined to the suburbs ; if possible, to parts where they are not likely to be encroached upon by buildings, and yet which are convenient of access and free from risk of danger, as will be explained. The sites of old burial grounds in the thickly-populated portions of a city may be altered to form open spaces and recreation grounds, as has been done with advantage in London and other places. The best soil is a good dry loam ; clay is bad, because, owing to its dampness, it retards dissolution and favours the formation of adipocere. In periods of drought, a clay soil is apt to fissure and so provide vents for the escape of carbonic acid and the gases of putrefaction. Chalk may be unsafe owing to the presence of cracks and "swallow holes," which may lead to the fouling both of air and water. Loose soils, such as gravel, are unsuitable. If there is a good and well-drained surface soil, a deep layer of clay may serve a useful purpose by protecting the reservoirs of underground water from pollution. The surroundings should be open, houses being at a considerable distance from the boundary walls, and no well or water supply should be in a position to be fouled by the drainage from a cemetery. The size is determined by the population, it being customary to allow one-fourth to one-half acre per 1000 persons. With more exactitude it can be obtained from the equation—

$$xz + \frac{65y}{100} \times 14 \times 4 + \frac{35y}{100} \times 8 \times 2 = x ;$$

where $x =$ the area in square yards required, $y =$ the number of deaths per annum, and z the proportion of the whole area unoccupied by graves, *i.e.* the spaces between lairs, walks, shrubberies, etc. ; z is usually taken as one-fifth, but by taking a larger proportion, such as one-half, provision may be made for future needs required by an increase of population. The rest of the equation is derived from the fact that of 100 deaths, 65 will be those of adults, and 35 those of children under 12 ; that for the former an area for each of 4 square yards, to be undisturbed for fourteen years, must be allowed ; and for the latter an area for each of 2 square yards, to be undisturbed for eight years. Area in square yards may be converted into acreage by dividing by 4840.

It is advantageous to plant trees and shrubs, which absorb carbonic acid from the atmosphere and dry the soil. A thorough system of drainage is important, and should be carried out before the ground is used at all. There must be a depth of at least 10 ft. of soil above any impermeable stratum or the subsoil water, and graves should not be more than 8 ft. deep. Not less than 2 ft. should intervene between the bottom of the grave and the water. A burial in the upper layers of the soil is more effectual towards the rapid dissolution of the body than burial at depths below 6 ft. Four ft. of soil should always cover an adult body, and 3 ft. that of a child under 12 years of age. A foot of earth must separate two coffins in the same grave. The products of decomposition are carbonic acid, ammonia, sulphuretted hydrogen, and various organic compounds. The air of cemeteries contains more carbonic acid and organic matter than ordinary atmospheric air, but if burial be properly conducted, no nuisance should result. Heavy wooden or lead coffins are bad, and should be replaced by those made of wickerwork, unprepared wood, or paper, which are much to be preferred, as "earth to earth" is the object of earth burial. The use of quicklime much facilitates the resolution of the body into its component parts. Danger to health may result from contamination of air or of drinking-water, but such danger does not bulk largely if the precautions above mentioned be enforced. It has been proved that pathogenetic microbes, with the exception of anthrax bacilli, rapidly disappear from graves, possibly in part because the soil of cemeteries is peculiarly rich in harmless bacteria.

Cremation is certainly preferable to earth burial, as by it exactly the same results are obtained in a fraction of the time, a body being reduced to a small quantity of ash in a little over an hour, and there being none of the dangers attendant on earth burial. The gaseous products are consumed in the crematorium, and no nuisance is produced, while pathogenetic organisms are completely destroyed. The only objection to cremation is the fact that it may cover crime, but elaborate precautions may be taken as regards the inspection of death certificates and corpses to ensure that death has been the result of natural causes. In this country, with our rapidly-increasing urban population and diminishing available land, it is desirable that cremation should supersede earth burial, at least in the case of large communities.

Mortuaries.—It would seem advisable for a sanitary authority to provide such places, where the bodies of those belonging to the poorer classes might await burial, thus obviating the dangers to the public health arising from decomposition proceeding in crowded and insanitary surroundings, and doing away with the necessity for hasty interment, which may be made a pretext for the concealment of crime.

OFFENSIVE TRADES.

The specified offensive trades are businesses connected in some way or other with the "working" of animal matter, which may either produce a nuisance or prove injurious to the health of the community. Their objectionable nature is almost always dependent upon the nuisance they create. In addition, there are many other industries which certainly produce intolerable nuisance if no sanitary precautions are observed in their management. The kind of illness which has been attributed to offensive odours is evidenced by nervous and alimentary disorders, *e.g.* headache, nausea, vomiting, diarrhœa, and the prolongation of the puerperium. Idiosyncrasy may determine the production and nature of the illness. Adjacent dwellings are apt to be insufficiently ventilated, since open windows admit foul odours, dust, and hairs from the trade premises. Under the English Public Health Act, 1875, the following trades are specified as offensive :—Blood, bone, soap and tripe boiling, fellmongering and tallow-melting, and any other noxious or offensive trade, business, or manufacture. Under the Scotch Public Health Act, 1897, the list includes the businesses of blood, bone, soap and tripe boiling, tallow-melting and manure manufacture, knacker, tanner, gut or tripe cleaner, skinner or hide factor, slaughtering of cattle and horses, and any other trade which the local authority may declare to be an offensive trade. A satisfactory method of classifying these multitudinous varieties of business is one founded on that of Ballard, namely, the source of the raw material of the trade, whether animal, vegetable, or mineral, or a combination of two or all of these. Under each trade will be considered the process, the nature and source of the nuisance, and its remedy.

ANIMAL.

Keeping of Animals.

Process.—The keeping of animals in stables, byres, and cowsheds, pigstyes and piggeries, and poultry-runs, within the precincts of a town or in any crowded neighbourhood.

Nuisances.—Badly constructed premises, old and dirty litter, emanations from decomposing dung and urine, fouling of the air with evil odours, imperfect drainage, ventilation, and water supply, and the attraction of additional and undesirable inmates, such as rats and insects. Close approximation to dwellings, especially as regards pig-styes, in the case of which also the storage of hog-wash may add to the nuisance. The noise of early cock-crowing is a common nuisance connected with poultry-runs.

Remedy.—Properly constructed premises for the keeping of animals, impervious pavement of concrete or of setts in asphalt and concrete. Slope of floor to drainage channel and trapping of main drain. Prevention of overcrowding of animals, 800 cubic ft. being the minimum required per head in byres and stables, which should be well lighted and ventilated. Manure heaps to be regularly and frequently removed, and to be covered from rain. Feeding troughs to be of fireclay or iron. Plentiful water supply and cleanliness, whitewashing, tarring, painting, and the free use of chloride of lime. Piggeries and poultry-runs should not be allowed in towns, and pig-styes should be more than 100 ft. from any house.

Slaughtering of Animals.

Process.—Slaughter-houses and knackeries may be either public or private, and not only are healthy animals, including horses, slaughtered in them, but old and diseased animals are killed, and the carcases of those which have died from disease and accidents are admitted. The animals are kept and fed in lairs before killing, and just before slaughter are detained in pounds. Many offensive trades besides slaughtering are often conducted on the same premises.

Nuisances.—The noise made by the accumulated animals, and the uncleanly state in which they are kept. Admission of diseased carcases, *e.g.* those with anthrax. Putrefaction of various materials permitted to accumulate. In private slaughter-houses the premises are often wholly unsuitable for the purpose, nor are public abattoirs always free from this reproach. Lastly, trouble may arise from the subsidiary trades, chiefly bone, flesh, and tripe boiling, gut scraping, manure making, blood-albumin factories, etc.

Remedy.—Proper situation of abattoirs; no dwelling should be within 100 ft., and the access should be good. Provision of public abattoirs, and abolition of private slaughter-houses. No part of the premises to be below the surface of the adjoining ground, and the premises to be thoroughly drained, well lighted and ventilated, and to possess a plentiful water supply. They should be surrounded by a high wall for purposes of seclusion. The slaughtering booth should have an impervious floor, but the concrete usually recommended has the disadvantage of splintering and cracking under the instrument used for cutting the heads from the carcases. Stone or asphalt is probably better, but whatever the material it should be smooth, sloped, and guttered towards a channel leading to a gully, which must be trapped and grated, the bars of the grating being not more than $\frac{3}{8}$ in. apart. The lower 6 ft. of the walls must be impervious, and are best tiled or cemented. Water must be laid on to the booth, and if a tank or other receptacle be present, its bottom should be not less than 6 ft. above the floor level. No water-closet, privy, or cesspool should be constructed within the slaughtering booth, and neither with any of these nor with a stable should the booth directly communicate. Iron material is better than woodwork wherever it can be employed. Properly constructed and covered receptacles must be used for the removal of manure, garbage, blood, etc., which should not be allowed to accumulate.

Blood-Boiling and Blood-Drying.

Process.—Blood is used for making (*a*) manure, (*b*) albumin, and in (*c*) Turkey-red dyeing and (*d*) sugar-refining.

(*a*) In making manure the blood may be treated with impure sulphuric acid, dried and mixed with other materials, or it may be dried on concrete floors heated below by steam-pipes, or it may be subjected to steam, the mass afterwards being stirred till it becomes a fine powder.

Nuisances.—The use of putrefying blood. Mixing with acid. Improper drying, *e.g.* on a stone floor with a naked flame (appalling stench!). Offensive odours from the boiling pans and driers.

Remedy.—Proper storage of blood in closed metallic vessels, so that the blood may be used fairly fresh. Mixture with acid to be done in a closed chamber, and vapours conducted through water or into a flue. Drying pavement to be cleansed at the close of every working day. Empty vessels to be thoroughly washed at once. Noxious vapours to be collected by hoods or pipes, and passed through a furnace or into a chimney. The methods commonly employed to render offensive vapours innocuous are condensation, destruction, and dispersal at a height, and these may be effected in different ways, namely—(1) absorption by water; (2) absorption by solids; (3) destructive distillation by heat in a closed vessel; (4) burning of all combustible and valueless gases; (5) employment of tall chimneys discharging far above the earth's surface. More than one of these methods may be used in combination. Absorption by water may be secured by means of a spray condenser, the water falling from the top to the bottom of a chamber, meeting and absorbing the gaseous fumes, accumulating and being drawn off. In some cases this water is then of commercial value. Charcoal alone may be used, or with water, as in the coke scrubber, in which a stream of water trickles through coke, meeting the gases which have been previously cooled, and purifying them. Drain pipes packed with coke make a cheap and efficient scrubber. The vapours may be collected in a pipe, and drawn or forced into the hottest part of a furnace fire, or passed through a fume cremator. This is the method specially applicable to the vapours emitted during blood-boiling.

(*b*) In MAKING ALBUMIN the blood is allowed to coagulate in a cool place in shallow pans; the clot is incised to permit escape of the serum, which drains through a sieve, is collected in a pan, and dried in shallow trays at 120° F. (50° C.).

Nuisance.—In this process there is little nuisance as long as the blood is fresh, and the factory well lighted and ventilated.

Remedy.—No storage of blood, and the conduction of the air through a combustion furnace.

(*c*) In TURKEY-RED DYEING the blood is used to fix the dye on cotton.

Nuisance.—The blood becomes putrid before and during use, and there is a constant smell.

Remedy.—General cleanliness; carrying on the fixing process in a closed chamber; extraction of vapours into a furnace or a high chimney.

(*d*) Blood is used to CLARIFY SUGAR, and the resulting scum may constitute a nuisance if decomposition is permitted.

Bone-Boiling.

Process.—The ultimate use of bones is to serve as manure, as a source of phosphorus, or as material for the making of knife-handles, buttons, etc.; but prior to such utilisation the bones are boiled to extract the fat and gelatine. Large and long bones are divided by sawing, and boiled under pressure, the process being carried on in a digester. The fat and gelatine separate out, and are drawn off.

Nuisances.—The smell of the bones, which are frequently allowed to accumulate in a "bone hole" till they dry, often undergoing decomposition. Vapours generated during boiling; these are very offensive, and easily diffused. Waste liquor after removal of fat and gelatine. Ammoniacal odour of heaped bones after boiling.

Remedy.—Proper storage of bones; prevention of accumulation; thorough daily cleansing, limewashing, and efficient drainage; boiling in steam-jacket pans to obviate the use of a naked flame; vapour condensation; cooling of waste liquor before entry to drains.

Soap-Boiling.

Process.—In the making of soap, fats and oils from various sources are employed; both animal and vegetable fats, often imported from abroad, and kitchen grease and débris are frequently utilised. To fit them for soap manufacture, the animal fats are rendered, *i.e.* freed from membranous matter. Their conversion into soap is effected by boiling them with a strong alkaline solution or "lye," the alkali used depending on the kind of soap required. Thus potash is used to make soft soap, and soda for hard soap. The alkali decomposes the fat into glycerine and the fatty acids, and combines with the latter to form the soap; when saponification is complete, common salt is added, and the soap rises to the top, and is transferred to moulds. The residue or "spent lees" contains the glycerine, which can be recovered from it. The boiling is conducted in metal pans set in brickwork, and the heat may be applied by naked flame to the bottom of the pans, or by steam-jacketing the pans, or by the injection of steam into the contents of the pans.

Nuisances.—Storage and decomposition of fats and oils; alkaline effluvia; boiling, especially if certain oils be used or the fat be scorched.

Remedy.—Proper storage of fats and oils in metallic receptacles with close-fitting covers; thorough cleansing of empty receptacles; use of as low a temperature as will suffice; discarding of the naked flame; pans to be lidded, and vapours to be conducted along pipes which perforate the lids, and convey the fumes to a fire or condensing chimney; general cleanliness and efficient drainage.

Fat and Tallow Melting.

Process.—It consists in melting fats derived from such sources as slaughter-houses, kitchens, knackeries, bone, glue, and tripe works. The fats are first "rendered," dried, minced, or chopped up, and then boiled in metal pans, which are heated by naked flames or steam-jackets. Sometimes steam is injected along with sulphuric acid into the contents of the pans. The greasy mass is then strained, the liquid fat collected in casks, and the solid residue, "greaves," used for manure and food for animals. The tallow may be used for soap manufacture, and in that case is washed; but if it is to be converted into candles, may be bleached by the addition of sulphuric acid and black oxide of manganese, or nitric and sulphuric acids and bichromate of potash may be added to it. The better class fats may be converted by the removal of part of their stearin into butter substitutes, such as margarine and butterine, but no nuisance is created in the process.

Nuisances.—The stinking condition of the stored fat; vapours from the boiling and during ladling; burning during melting; storage of "greaves."

Remedy.—Proper storage; mechanical ventilation of the room where the fat is sorted out of the storage vessels; use of closed pans, steam heat, and fume destruction; avoidance of high temperature; general cleanliness; lime-washing, and preservation of the premises in good repair.

Tripe-Boiling.

Process.—Tripe, the first stomach of the ox or sheep, is boiled to prepare it for human food. Its contents are evacuated in the slaughter booth, and it is thereafter washed, scalded, and scraped. It is then boiled either in a boiler or steam-jacketed pan. After this it is hung up to drain, the fat utilised for soap-making, and the water discharged down a waste pipe. Ox feet and sheep's trotters are frequently boiled along with the tripe, but are first deprived of skin, and the valuable fat is used for making neat's-foot oil.

Nuisances.—The raw material is frequently offensive, and so is the prepared article when indiscriminately cast out of the boiler, and allowed to lie in heaps on the ground. Vapours from boilers or pans during the process, or when being emptied.

Remedy.—The plentiful use of water in cleansing materials and premises. Ventilation of the cleansing and boiling rooms. Use of lidded pans and boilers. Vapour condensation. Cooling in cold chambers or closed sheds connected with a chimney. Employment of a sufficiently large staff of workers to obviate the accumulation of offensive materials.

Flesh-Boiling.

Process.—Inferior meat is boiled to obtain the fat, to render the flesh fit for human food, and to make cats'-meat. Much the same remarks apply to it as to tripe.

Gut-Cleaning and Gut-Spinning.

Of all the offensive trades this perhaps causes the most intolerable nuisance.

Process.—This process is carried on for the purpose of making catgut, fiddle-strings, and sausage skins from the small intestines of sheep and hogs. The raw material may be brought from a distance, and is first washed, cleaned, and soaked in brine for some days, and then in water. By this means the mucous membrane is prepared for removal, and, after scraping with a piece of hard wood, a part of the muscular coat and the peritoneum are alone left, and they are thrown into water. For sausage skins, packing in salt is considered sufficient, but in the case of fiddle-strings, for which only fresh gut can be used, the gut is sewn in lengths, soaked in solution of sodium carbonate for a week (the solution being changed twice daily), and finally spun.

Nuisances.—Decomposition and storage offence. General filth and unsuitability of premises. The odour diffuses powerfully.

Remedy.—All gut from a distance should be conveyed in tight metal barrels, which should only be opened in the scraping-room, and the air of the scraping-room should be sucked out by a fire connected with a chimney, while free ventilation should be provided. The floor and walls for 6 ft. up should be impermeable, and the scraping-table should be of stone. Ample water supply, thorough daily cleansing, and the use of deodorising solutions for the floor and walls, such as sulphite of soda. For stinking gut and liquor, chlorinated water or chloralum should be used as a deodorant. Limewashing and efficient drainage of the premises.

Bacon-Curing.

Process.—The pig's carcase is scalded and washed, the hair sometimes being singed before scalding. The hair is then removed by scraping, and the meat dried in smoking chambers, or steeped in brine.

Nuisances.—Smell created by burning hair. Fumes from smoking chambers or brine.

Remedy.—Douching carcase with cold water after singeing. Closed chambers for the whole process, and fumes dealt with in the usual way.

Fellmongering.

Process.—The preparation of fresh or old foreign skins for the leather dresser. Recent skins are cleared of any adherent flesh, beaten with a mallet or sticks to remove dirt, and soaked in water. The skin is then placed in lime-pits, or lime is rubbed into the inner side of the hide, which is then hung up, and the hair or wool plucked out by hand. Foreign skins are generally hard, and are soaked and allowed to decompose until the hair or wool can be easily detached. This is termed the "tainting" process. When this stage is reached in both instances, the hide is known as a "pelt." The pelts are thrown into milk of lime pits, dried, and are then ready for the leather dresser.

Nuisances.—The premises are frequently unsuitable, and in a foul and dirty state. Storage of hides and decomposition of adherent flesh. Slight odour from tainting process. Accumulation of dirt and refuse. If washing be done, as it frequently is, in a stream, a nuisance is created under the Rivers Pollution Prevention Act. Ammoniacal odours and the removal of waste lime from the lime-pits.

Remedy.—Proper premises, general cleanliness, water-tight pits, smooth, impermeable, and well-drained floors. . Scraping and limewashing of walls. Ample water supply, and water not admitted to a stream without purification. Frequent emptying of lime-pits, at least once a day.

Leather-Making.

Process.—The pelts are limed in pits for three weeks, then washed, and then immersed in "puer," a mixture of water, pigeons' manure, and dogs' dung, for two days. Next they may be bleached by soaking in bran and water, and are then "tanned" by washing in warm water and soaking in tannin solutions, *i.e.* oak bark, catechu, or any one of a large variety of substances. Tanning is conducted in pits lined with cement, stone, or brick, and the pelts are usually passed through three strengths of tanning liquor, beginning with the weakest. The leather is then hung up to dry, and allowed to sweat in heaps, scraped, oiled, and rolled. After tanning, currying is the final process, whereby the leather is rendered flexible by heat and oil.

Nuisances.—Odours from lime-pits and from "puering," drench, and tanning pits. Burning of waste tan. From foreign skins which have been preserved by arsenic, vapours of arsenious acid and sulphuretted hydrogen may be evolved during the process.

Remedy.—Much the same as mentioned for the process of fellmongering, and, in addition, "puer" pits should be placed in a special building, the air of which is passed up a high chimney or through a fire. Tan waste should be rolled, not burned. Skins which have been preserved by arsenic should be treated with salts of iron to form insoluble arseniates.

Glue-Making.

Process.—Damaged hides, pelts, hoofs, horns, bones, and animal waste are utilised for making glue. The blood, oil, hair, and dirt are removed by liming, and the raw material is then washed, boiled with water, and continuously stirred; after settling, the fatty material is skimmed off, and the liquid glue is run into troughs, solidified by cooling, and then cut into slabs. The residue or "scutch" is boiled and pressed to get rid of all grease, and is then used as manure.

Nuisances.—The main offence arises from the "scutch," which, if allowed to accumulate in the open air, gives off a smell, "ferocious, sickening, and capable of travelling long distances with the wind." The nature of the material used, and the offensive vapours from the vats.

Remedy.—"Scutch" to be carefully and at once removed in proper receptacles. No accumulation of raw materials. Drying of such prior to storage. Vapour destruction or condensation and dispersal by means of a high chimney.

Size-Making.

Process.—It resembles that of glue-making, but only good materials are used, and there is little nuisance.

Hair Preparation.

Process.—The preparation of the hair of such animals as horses, cows, and pigs for industrial uses, mattresses, upholstery, etc. The hair is first sorted according to the length and colour, then washed, dried, and combed. It may be bleached or dyed, and is then curled, steeped in cold water, and the curl rendered permanent by heat. The short hairs are teased out and dusted in a machine, the fine dust discharged, and the heavy dust used as manure.

Nuisances.—The fine dust; the vapours from the dye vats; the hot liquor discharged into drains; the danger of anthrax.

Remedy.—Dust to be discharged into a furnace flue. Dye vats to be lidded. Vapours collected by hoods and conducted to condensation chambers. Liquors to be cooled below 80° F. before discharge into drains. Rules for the prevention of anthrax are the same as those detailed under Wool-sorting.

Wool-Sorting.

Process.—The wool of the fleece is separated according to its quality, and the process is conducted on a wire-grating over a dust chamber. The fleeces are often imported from abroad.

Nuisances.—The dust used during the opening of the bales and the sorting of the wool. Frequency of anthrax, especially in the foreign fleeces brought from Armenia, Persia, and South America.

Remedy.—Disinfection of materials before sorting. The regulations suggested by Dr. Hime and adopted in Bradford, the chief seat of this industry, are briefly as follows:—Bales of wool and hair to be opened only by a skilled inspector; if contents are sound, sorting ensues, but if noxious, they are disinfected or steeped in water, washed in hot suds and rolled before sorting. All foreign materials and damaged goods are to be regarded as noxious. Noxious material is not to be opened in the sorting-room, but in a special room, and over an extraction fan. In the sorting-room each sorting-grating is to be separately connected with the extraction shaft, and the dust drawn downwards or horizontally away from the sorter. The dust collected by the extraction fans is to be gathered in catch-boxes and burned, together with the sweepings of the sorting-room and waste materials. Disinfection of clippings, etc., before sale or use. No sorter is to be permitted to work while there is any abrasion or open sore on the skin. Meals are not to be taken in the sorting-room, nor clothes allowed to be in it. Mechanical ventilation of the sorting-room and disinfection and limewashing twice a year.

Daily sweeping after moistening the floors with a disinfectant. Lavatory accommodation in or near the sorting-room, and provision of means for the prompt treatment of scratches, etc. No storage of wool or hair in the sorting-room.

Fish-Frying.

Process.—This consists of frying fish in oil, especially cotton-seed oil, in open pans heated by a naked flame.

Nuisance.—Chiefly due to the oil, which is decomposed by heat, giving off empyreumatic odours, of which that of acrolein is the most offensive.

Remedy.—The substitution of steam-jacketed cylinders for the pans and naked flames, or the use of vessels allowing a depth of oil sufficient to prevent burning. Hoods over the pans and a gas jet to provide draught up the flue.

VEGETABLE.

Drying and Storage of Grain.

Process.—This is often connected with the keeping of animals, and adds to the nuisance thus created. The process consists in the drying of draff over floors heated by steam, the draff being the residue of the malted grain after infusion.

Nuisance.—Both in the case of draff and of grain which is damp owing to bad storage, acetous, butyric, or lactic fermentation may occur, and give rise to offensive odours.

Remedy.—Mechanical ventilation of drying-room; proper premises for storage; prompt use of draff.

Flax-Making.

Process.—The fine fibres of the flax are obtained by rotting away the outer coarse fibres either by steeping the flax in water in open-air channels ("lint steep"), or in tanks in which the temperature of the water is maintained at 80° F. by the injection of steam. The flax is then rolled and dried.

Nuisances.—These arise from the fermentation and decomposition of the vegetable matter, resulting in butyric and valerianic acids being formed. Subsequent rolling also gives rise to a nuisance. Discharge of hot liquor into drains, or of the water from the lint steeps into a water-course.

Remedy.—Vapours from the tanks to be discharged by a high chimney, and the tanks to be in covered sheds. Purification of the effluent before discharge into any water-course.

Paper-Making.

Process.—Rags, straw, hemp, waste paper, wood pulp, esparto grass, and other materials are used for paper-making. With the exception of esparto grass, they are first freed from dust, cut up, washed, and bleached, while esparto grass is freed from impurities by picking. The materials are then boiled with caustic alkali, and a pulp obtained, from which the paper is made by machinery. The alkali is recovered from the liquor or lye.

Nuisances.—The alkaline liquor gives off a very offensive odour, especially if esparto grass has been used. The vapours given off during recovery of the soda, and the scorching of the residue, constitute a still greater nuisance. Discharging of the liquor into streams.

Remedy.—To conduct the boiling process in special chambers, from which the vapours are conducted to a furnace or tall chimney. Liquor not to be discharged into a stream or a ditch adjacent to habitations.

Oil Cloth and Linoleum Manufacture.

Process.—Oil-cloth is made from canvas coated with size, or with blood and lime, and then with thick paint. It is dried, and the patterns imprinted. Linoleum is made from finely-powdered cork mixed with linseed oil, rosin, and kauri gum. The rosin and gum are rubbed up and heated in a steam-jacketed pot to form a cement, which is then mixed with the oil, cork, and pigment.

Nuisances.—These arise during the drying of the oil-cloth and the heating of the rosin and gum for linoleum manufacture.

Remedy.—Passage of the vapours through a water-bath and then into a furnace.

Varnish-Making.

Process.—Various oils, resins, and gums are used, and are melted and fused with the addition of mineral substances.

Nuisances.—Irritating and offensive vapours are given off, among which that of acrolein is prominent.

Remedy.—Hooded pipes over the boiler pot; extraction fan and furnace: destruction of vapours.

Indiarubber Manufacture.

Process.—Commercial rubber is purified by boiling and washing, and is made up with sulphur or sulphide of antimony. It is then treated with naphtha.

Nuisances.—Vapours given off during boiling; sulphur, carbon disulphide, and naphtha vapours; steam discharges; and drying of vulcanised rubber.

Remedy.—Covered vessels: mechanical ventilation; vapour destruction.

MINERAL AND MIXED PROCESSES.

Alkali Works.

The term "alkali works" includes a very large number of industrial processes which are enumerated in the Alkali Works Regulation Act, p. 564.

Process.—The chief process consists in the manufacture of sulphate of soda (salt cake) from sodium chloride and sulphuric acid, and the subsequent preparation of sodium carbonate, by heating the salt cake with coal and lime, whereby "black ash" is formed. From this the carbonate of sodium is dissolved out by water. The residue contains carbon and sulphur, and this "alkali waste" is offensive, by reason of the ease with which it is made to evolve sulphuretted hydrogen. Other processes consist in the manufacture of sulphuric acid from iron pyrites, of chloride of ammonium (sal ammoniac) from gas liquor and hydrochloric acid, and of ammonia from gas liquor.

Nuisances.—The nuisances associated with such works arise not only from the vapours emitted during the process, but also from the waste products formed, since even slight moistening of the alkali waste by rain is sufficient to set free sulphuretted hydrogen. The vapours emitted from the works are frequently strongly acid and destructive of vegetation, and rain falling through an atmosphere loaded with acid vapours, becomes sufficiently acid to decompose alkali waste.

Remedy.—Condensation of gases evolved. Water sprays or coke scrubbers should always be used, and the final vapour allowed to escape must not contain more hydrochloric acid than $\frac{1}{5}$ gr. in each cubic ft., nor more anhydrous sulphuric acid than 4 grs. per cubic ft. Alkali waste and acid drainage must be rigorously separated.

Chemical Works.

Processes.—A very large number of different processes are included under this term, such as ore smelting, calcining, distillation of tar, wood, etc., preparation of organic acids, etc. etc.

Nuisances.—The evolution of such vapours as sulphurous acid, nitrous acid, sulphuretted hydrogen, carbon dioxide, carbon monoxide, marsh gas, chlorine, and empyreumatic vapours.

Remedy.—Vapour condensation or destruction, the furnace being in many cases the most satisfactory method. Treatment of vapours with such chemical substances as will combine with them to form inoffensive bye-products.

Coal Gas Works.

Process.—Coal gas is the purified product of the destructive distillation of coal. The process is conducted in iron retorts to which access of air is prevented. The gases given off are coal gas, volatile hydrocarbons, carbon dioxide, carbon monoxide, ammonia, nitrogen, oxygen, and hydrogen, sulphur compounds, and sulphuretted hydrogen, together with various tarry matters and water vapour. Purification consists in—(1) the condensation of watery vapour and tarry matters, by cooling during the passage of the gas through a length of piping; (2) the removal of heavy coal tar and ammonia, by passing the gas through coke scrubbers; (3) the removal of sulphur compounds and carbonic acid, by passing the gas over lime exposed on shelves; (4) the absorption of sulphuretted hydrogen, by passing the gas over an oxide of iron distributed on shelves. The purified gas is conducted to, and stored in, gasometers, which are sealed in water-tanks. The bye-products of the process are—(*a*) the coke which is left in the retorts after distillation; (*b*) the condensed tarry matters, ammonia, and water, which are conducted to a tar well, and subsequently separated by distillation; (*c*) the lime waste; (*d*) the iron waste.

Nuisances.—Offensive smoke and crude gas from the retorts during filling and emptying. Water gas produced when hot coke is cooled with water. Sulphuretted hydrogen and carbon disulphide from lime waste, if the iron process be omitted. Dust from waste lime during its removal.

Remedy.—Care in working retorts. Prevention of leakage. Lime waste to be frequently removed, and to be moistened before removal. Use of iron sesqui-oxide for the removal of sulphur and of lime for the carbonic acid. Absorption of sulphur by lime to be of limited extent.

Processes with Poisonous Metals and Pottery Manufacture.

The processes in which these metals are used chiefly cause danger to the workers, and are not so inimical to the health of the community at large.

The ill effects and their remedies have been fully considered in the section on Medicine. Actual nuisances are rare, and their remedy can usually be found in vapour condensation or destruction.

Ballast-Burning.

Process.—Clay earth excavated during building operations is burned to form "ballast," a kind of clinker used with cement for making roads and pavements. The nuisances are much the same as in brick-burning, and the remedy is interdiction of the process anywhere near human habitations.

Brick-Burning and Cement-Making.

Process.—Brick-burning consists in the burning of clay, chalk, sand, or brick-earth to form bricks. It may be performed in clamps or kilns. In clamp-burning, layers of bricks are alternated with breeze and house refuse used as fuel. The mass is lit by means of coal or wood fires, and when fairly alight the fire is damped down by green-tree branches, so that the whole pile is allowed to slowly burn till the bricks are incinerated.

Nuisances.—The ordinary products of combustion, and offensive vapours from the organic matter in the clay and house refuse. Dense smoke from the green fuel.

Remedy.—Interdiction near any populous place.

In kiln-burning the bricks may be burnt in an open or closed kiln without admixture of carbonaceous matter. In closed kilns provided with a chimney there is little nuisance; but in open kilns, if inferior fuel be used, sulphurous gases may be evolved. The making of Roman cement from septarian nodules is done in kilns, and is inoffensive; but in Portland cement-making the clay or chalk mud, when calcined, gives off offensive and dangerous vapours, carbon dioxide, carbon monoxide, sulphuretted hydrogen, and volatile cyanides. The remedy consists in passing the fumes up a very high chimney.

Manufacture of Artificial Manure.

Process.—This is an important and increasing industry, in which all kinds of waste are used up, such as the refuse from the offensive trades dealing with animal substances, night-soil, fossil remains, coprolites, soot, tar, charcoal, scum from sugar refineries, gypsum, various earthy salts, and certain salines. The chief variety of artificial manure is superphosphate, in the preparation of which ground bones and mineral phosphates are mainly employed. The organic matter is subjected to the action of steam, and afterwards dried. To it are then added the earthy and mineral phosphates powdered by grinding; the combined materials are mixed and stirred, and sulphuric acid is slowly added during this process, and causes the evolution of much heat. The mass is then transferred to shallow brick receptacles, known as the "hot-den," where it is allowed to cool, set, and undergo certain chemical changes. It is then dug out, ground, and packed for sale. Poudrette, another form of manure, is made by treating night-soil with sulphuric acid.

Nuisances.—Nature of the organic materials used, such as decomposing bones, shoddy, scutch, putrid fish, and potted meats, and flesh unfit for human food. Vapours from the steaming pans. Impurity of the sulphuric acid used, which frequently contains arsenic from the iron pyrites, and may give off arsenical fumes. Offensive odours from the "hot-den," persisting for several days during cooling. Absence of separate "hot-den," in which case the mass may be allowed to cool on the ground. A sickening and abominable odour is given off in poudrette manufacture.

Remedy.—Proper storage in air-tight receptacles, and prevention of accumulations of rotten materials. Mixing to be done in covered vessels, and the "hot-den" not to be in the open air, but in a building whence vapours can be conducted to destructors or condensers. Care must be taken that the flues do not get blocked with silica, derived from a fluoride of silicon, which may be formed during the process. General cleanliness.

SMOKE PREVENTION.

The products of complete combustion are gases which are imperceptible; but if combustion be imperfect, smoke is produced. In this country the use of coal as the almost invariable fuel, and its incomplete combustion, result in the generation of large quantities of smoke, leading to fog, mist, and many minor evils. Coal smoke consists of vapours containing particles of fuel in suspension. Its two chief oxidisable constituents are hydrogen and carbon. The former is capable of oxidation at a lower temperature than the latter, so that, unless smoke vapours while at a high temperature are supplied with ample atmospheric oxygen, the heavier carbonaceous matter is not oxidised, but deposits in the shape of soot, while that which is lighter floats in the air till washed out of it by rain. Fog is not entirely due to smoke, as other forms of dust besides that of coal may give rise to it, but the dark colour of fog is largely caused by unconsumed carbon. With regard to smoke prevention, the question of how best to deal with house fires, and with furnace fires, has to be considered. In the case of both, much might be done by altering the fuel employed, did not the bugbear expense stand in the way. Thus, if gas could be used instead of coal for domestic purposes, at a cost not greater than that of the coal, a marked advance would be made in dealing with the smoke question in non-manufacturing towns. In the case of furnaces, the quality of the coal employed is part of the evil. Anthracite coal and coal dust can be combusted without the production of black smoke. Now anthracite is dearer, weight for weight, than ordinary coal; but, on the other hand, its heating power is so much greater that less of it has to be used, and in practice it is probably very nearly as cheap as ordinary coal. It has not, however, the steam-producing power of the latter. A comparison between the atmospheric conditions of continental and British manufacturing towns demonstrates the superiority of coke as a fuel, as far as smoke production goes; while coal dust is recommended, not for any virtue in itself, but owing to the method in which the furnace fire can be fed with it. As in house fires, so in furnaces, gas may be utilised, as seen in the case of the new Siemens gas furnace, which is both smokeless and economical.

The Government Commission found that the causes of smoke nuisances in furnaces were—

1. Want of proper construction and adjustment between the fireplaces and the boilers, and the disproportionate size of the latter to the amount of work they are expected to perform.

2. The deficiency of draught and improper construction of the flues leading to a chimney of inadequate height and capacity.

3. The carelessness of stoking and management in those entrusted with the charge of the fireplaces and boilers.

The remedy for the first set of conditions is obvious. As regards deficient draught, various devices are in vogue to supply an adequate amount of air to the furnace fires, having as their object—

(*a*) The admission of sufficient air for complete combustion, but no great excess, as such escapes at a high temperature and there is thus a loss of heat.

(*b*) The intimate contact of the air with the fuel.

(*c*) The mixture of air and fuel must be kept for the necessary time at an incandescent temperature.

Air may be admitted at the "bridge," behind the fire-bars through a perforated plate or the bridge may be split, at the furnace door, through openings which work automatically or are managed by the stoker, or through hollow fire-bars. Another method is the distribution of heated and slightly-compressed air, through hollow grate-bars, to the whole lower surface of the furnace. A forced draught may be obtained by the aid of steam-jets directed into the furnace, or by fans. Human labour may be replaced, or rather supplemented, by mechanical means devised to improve the stoking, and thereby the combustion process. The two chief kinds are the coking and sprinkling stokers. The former feed the front of the fire, and the fuel is slowly moved backwards in the furnace till it is discharged as clinker into the ash-pit. In this way the vapours from the fresh fuel have to pass over the glowing contents of the furnace, and are rendered smokeless before reaching the flue. The furnace may also be fired from the sides alternately for a similar purpose, and with a similar result. The latter, which are not so good, provide for an equal distribution of fuel, in small quantities at a time, all over the fire surface, and their efforts to keep the fire level and prevent accumulation at any part are supplemented by fire-bars which move automatically and rake the furnace from below. These and other methods prevent firing at irregular intervals and in varying amounts by the attendants, practices which lead to imperfect combustion and much smoke emission. Smoke-washing by means of a water-spray removes soluble gases, but does not greatly diminish the amount of carbonaceous matter. Smoke may be consumed by passing it through a fume cremator or a coke furnace, but such methods are too expensive for general use; while fans, forcing the smoke to again traverse the fire from which it was emitted, have not proved very efficient in practice. Whatever mechanical appliance be adopted, proper supervision by skilled and careful workmen is essential.

While any factory furnace which does not consume its own smoke constitutes a nuisance under the Public Health Act, it is customary to allow the emission of dense smoke for a short period at the hour of rekindling fires, and only to prosecute thereafter if smoke be emitted for a period exceeding from one to ten minutes in an hour, the exact time varying in different towns, and often with the number of boilers connected with the chimney. For further information on this subject, the reader is referred to the report submitted to the corporation of Sheffield by its late medical officer of health, Dr. Harvey Littlejohn, and the United States Consular Report, 1899.

SANITARY ENGINEERING AND BUILDING CONSTRUCTION.

"Crescent and street and square I build,
Plaster and paint, and carve and gild:
Around the city see them stand,
These triumphs of my shaping hand,
With bulging walls and sinking floors,
With shut impracticable doors,
Fickle and frail in every part,
And rotten to their inmost heart.
There shall the simple tenant find
Death in the falling window blind,
Death in the pipe, death in the faucit,
Death in the deadly water-closet!
A day is set for all to die:
'Caveat emptor!' what care I?"

(*Song of the Jerry-builder.*—R. L. S.)

Civilised man requires a habitation, and, being a gregarious animal, one dwelling soon leads to another, the house becomes the hamlet, the hamlet the town, and the town the city. A suitable site having been secured and a sufficient shelter provided, man's further needs include a good water supply, ample air, and, if his health is to be preserved, an efficient method for the removal of his excreta. Provision for the education of children, the treatment of the sick, and the housing and slaughtering of animals, is also a question concerning all communities of any size or importance.

This section must therefore include the following subjects:—

1. The erection of healthy houses, from a structural point of view.
2. The structural arrangement of houses and groups of houses to form a town or city.
3. Ventilation, warming, cooling, and lighting.
4. The collection and distribution of a pure water supply.
5. The disposal of sewage and refuse, and the drainage of sites and subsoils.
6. The testing of general sanitary arrangements.
7. The construction and arrangement of hospitals, sanatoria, schools, workmen's dwellings, cowsheds, and slaughter-houses.

I. THE ERECTION OF HEALTHY HOUSES, FROM A STRUCTURAL POINT OF VIEW.

1. *The Site.*—An ideal site is one at a fair elevation above sea-level, allowing free air circulation around it, sheltered from cold winds, well warmed

by the sun's rays and of suitable geological formation, such as gravel, hard rock, or porous sand, provided the foundations are reliable. Further, the soil should slope away on all sides to secure proper drainage, soil and subsoil should be clean and not of the nature of what is known as a "made soil," the level of the underground water should not approach nearer to the surface than 12 or 15 ft., and the ground water itself should not be liable to rapid or extreme fluctuations.

Even in this country these favourable conditions are rarely realised in their entirety; but in every case the importance of avoiding a "made soil" and a site where the ground water is constantly high, cannot be too strongly insisted upon.

The danger arising from absence of the other conditions can be obviated by various artificial means.

A site may be undesirable owing to—

(*a*) *Contamination of soil and subsoil by organic matter.*—In this case time is the only real remedy, several years being required before a soil can purify itself by the process of nitrification, which is aided by aeration and drainage. All houses built on "made soil," whether such soil be recent or otherwise, should be provided with air-proof basements.

(*b*) *A level of ground water within* 5 *ft. of the surface, or a level fluctuating at frequent intervals, especially between* 15 *and* 5 *ft. from the surface.*—These conditions may or may not be amenable to improvement by drainage. But little can be done in such places as flat valleys surrounding lakes. In the case of a house situated on flat land near the base of a hill, the level of the ground water at the site is maintained by the pressure of the water in the higher ground. Good may result from digging a deep trench between the house and the hill, thus intercepting the drainage of the hill and diverting it from the site.

(*c*) *The nature of its soil constituents.*—As already stated, gravel, hard rock, and porous sand form ideal sites under certain conditions. A gravel or sandy site situated in a hollow may be water-logged and distinctly unsuitable. A layer of underlying clay or an admixture with clay, by interfering with their permeability, may spoil otherwise good gravel or sandy sites.

Pure chalk is to be recommended as a site, since it is both permeable and free from damp. If, however, it be mixed with clay, forming what is known as marl, or be underlaid by clay beds, it holds large quantities of water, and is to be condemned. If efficiently drained, granites, clay slates, limestones, and sandstones form eligible positions, but they are apt to be cold, and in the case of limestones superincumbent marshy ground is frequent. Heavy loams and stiff clays are unhealthy when damp, and usually require extensive drainage operations to render them suitable.

(*d*) *Exposure to cold winds.*—In this country these are commonly from the east and north. Much may be done by tree-planting to obviate this drawback.

(*e*) *Want of fresh air.*—The surroundings of the site may be cumbered with trees, or the configuration of the ground may prevent free atmospheric circulation. A space should be cleared round the house in all cases.

(*f*) *Deficiency or excess of sunlight.*

(*g*) *On account of surroundings.*—Thus the site may be in danger of flooding if situated in a deep valley with a restricted outlet. Organic matter may constantly be washed down upon it if it be placed at the base of impure higher ground. In many enclosed valleys there is not a sufficient circulation of air, and there is a paucity of sunlight. There may be unhealthy marshes in the vicinity, or no suitable water supply or means of disposing of refuse and excreta. Neighbouring industries may render a site untenable by reason of foul odours, noxious vapours, and other factors.

2. *Aspect.*—Having chosen a suitable site, the next question relates to the placing of the house upon it; in other words, the relation of the building to the four points of the compass. In this country the house should front the south, thus avoiding the extremes of heat and cold. A northern aspect is bad, lacking both light and warmth; an eastern is warm in summer and cold in winter; whilst the western does not receive the sun till too late in the day, and may then obtain too much of it. A south-western exposure is often all that can be desired.

3. *Plan.*—The chief rooms should face south. So should bedrooms intended for old and sick persons. The apartments destined for the commissariat department should have their windows to the north.

4. *Foundations.*—These should be sufficiently solid and deep-rooted to afford stability. If firm foundations cannot be obtained in the site, it is necessary to make artificial ones out of large blocks of concrete, on which the walls may rest. Each of these should be at least four times the breadth of the wall it supports, and at least 18 in. in depth. They ought not to be laid during frosty weather.

5. *Materials.* — The shell of a house may be constructed of a variety of materials, such as concrete, mortar, stone, bricks, wood, plaster, iron, and canvas. We are here only concerned with the ordinary stone or brick house.

Concrete consists of a homogeneous matrix of cement, interspersed with broken brick or stone, or with gravel. The matrix usually employed is Portland cement. It is made from lime and a peculiar dark blue mud-clay from the lias formations. This clay has to be subjected to treatment to free it from organic matter, and is then mixed with the lime in the proportions of 1 part of clay to 3 parts of white chalk, or 1 part of clay to 4 parts of grey chalk. The mixing is done in a large vat by means of a revolving spindle, water having been added to the constituents. A creamy mass results, which is run into shallow tanks and allowed to settle. The supernatant fluid is rejected, and the sludge is conveyed to coking ovens, over which it is dried on iron plates. Its next destination is the kilns, where it is burnt to vitrification, then ground, and spread out to dry. It is then ready for the market, and is sold as a powder by the bag or bushel. Samples are tested at the various stages, as it is impossible to remedy defects in the manufactured article. Portland cement is one which will set either in the air or under water, hence it possesses hydraulicity. A good sample should be bluish grey in colour, and should not be gritty when rubbed between the thumb and forefinger. It should have a definite weight, a fair average being 110 to 112 lb. per bushel. The lighter cements set more quickly under water, but are not eventually so strong. A good cement should set under water, and after seven days' immersion should resist fracture by a pulling strain of 300 lb. per square in. of the cross section of the little briquette, which is the form in which it is tested.

Sand, though it reduces strength, is added to prevent cracking in the finished material. As already stated, cement only forms the matrix of the concrete, which may be composed of 1 volume of cement to 6 parts of gravel and sand. The ingredients may be mixed dry and water added subsequently, or the water may be added at the time of mixing.

Mortar.—Ordinary mortar consists of carbonate of lime, and is made by driving off the carbonic acid through the agency of heat. The oxide results, which on the addition of water becomes the hydrate, and this taking up carbonic acid and re-solidifying into the carbonate forms mortar. This process is performed to obtain an insoluble material, ordinary carbonate of lime being soluble in water. Clean sharp sand is added to the hydrated lime in the proportion of 3 to 1 to prevent shrinkage. A special mortar or cement is that containing lime, alumina, and silica, such as is obtained from nodules (clay iron-stones) occurring in various geological formations. On burning the raw product, silicates of lime and alumina are formed; and when the mass is powdered and mixed with water, a double silicate of lime and alumina results, which is insoluble in water.

Mortar should always be used fresh, as, if allowed to stand, it loses much of its adhesive quality.

Stone.—The rocks most commonly used in building are sandstones and limestones, as they are both very plentiful and easily worked. The latter fact explains the term "freestone" applied to both these varieties. In certain parts of the country where granite is plentiful, it is largely used, while syenite, trap rocks, schists, slates, and shales may all enter into the construction of a building. The best sandstones are those with siliceous matrices, though several varieties of good stone are argillaceous (clay-containing).

Limestones are partly calcareous, and may contain clay or silica. A good proportion is 11 parts carbonate of lime to 3 of silica and 1 of clay. Oolites are preferred to the dolomites, as they decay less rapidly. The grey Scottish granite is the most durable of granites, and those containing much felspar are unsuitable, owing to its rapid and ready weathering. Granite is specially suitable for foundations. Stone has to be dressed; this is done by hammer (scabbling), or by chisel and mallet.

Bricks.—Bricks are made from "brick earths," which may consist of pure clay, clay loam, and clay marl. Pure clay is chiefly alumina and silica, and, on burning, a silicate of alumina is formed, which will stand a high temperature, hence it is used for fire-bricks. Clay loam is a mixture of clay and sand. Clay marl contains carbonate of lime, clay, and usually some protoxide of iron, which, on heating, takes up more oxygen and turns red.

A good brick earth is composed of two-thirds silica to one-third alumina, and mixtures of the brick earths are commonly employed.

The brick earth, having been dug out in autumn, is formed in heaps and allowed to weather during the winter. It is then broken up with spades and mixed with water in a wash-mill by means of a revolving spindle. The sticky mass is now worked into bricks either by hand or machinery. The bricks are dried, stacked in "hacks" under sheds, where they are freely exposed to the air, and, when quite dry, are burned in kilns or clamps.

Brick-burning constitutes an offensive trade, and the process is described on p. 301. After burning, the bricks are sorted into classes according to quality. A "purpose-made" brick is one fashioned for a special purpose either as regards shape or quality.

A brick should be well shaped, and all its angles should be right angles. The edges or solid angles should be sharp and clean. It ought to weigh 5 lb., be twice as long as it is broad, and be homogeneous in character and colour both externally and on section.

The common dimensions are 9 in. by $4\frac{1}{2}$ in. by 3 in. A brick can absorb as much as 1 lb. of water, but it should not be over-thirsty, 5 to 10 oz. being a moderate allowance. Bricks have to withstand simple and compound stresses, and a good brick when placed on end should resist $\frac{1}{2}$ lb. per square in. of surface exposed to the stress. An excellent rough test as to the quality of a brick is the character of the sound elicited by striking it with a hammer. A good brick emits a clear, ringing note.

Wood.—For structural purposes exogenous timber is used. In this country the supply chiefly comes from the Baltic and North America, and consists of hard woods such as ash, oak, and elm ; and conifers such as pines, firs, larches, and cedars. Quality of timber depends on its rate of growth and its original position in the stem of the tree. The slower the growth and the nearer the centre of the tree, the better the specimen. A rough comparative test is the musical note given out by the wood when it is struck by a hammer. A good dense wood gives a clear, ringing note. Timber comes into the market in the shape of balks, half-balks, planks, deals, battens, and boards, terms varying with the shape, length, and thickness of the sample.

Seasoning of timber.—This consists of dissolving out the albuminous matter, and then drying as thoroughly as possible.

The wood of a building is subjected to various strains, and tensile, shearing, and crushing stresses have to be tested accordingly.

Strength depends largely upon the arrangement of the vascular bundles and the medullary rays.

No timber can withstand alternate wetting and drying, or heat and moisture without adequate ventilation. Under such conditions decay sets in, especially if lime be adjacent, hence the ends of beams are liable to early degeneration. Two peculiar diseases affect timber, namely, dry and wet rot, the exciting causes in all probability being fungi. Wood suffering from either form of rot must be condemned and removed. Protection from decay is best secured by forcing creasote into the wood under pressure (Bethell's process), though metallic substances are also employed as wood preservatives. The woodwork of a house is kept in good condition by painting and varnishing.

Plaster.—Its chief ingredient is lime or cement, and, in addition, it contains sand, hair, and sometimes a little sulphate of lime.

6. *Basement.*—A house may have its walls founded upon concrete or granite blocks, and if the latter be employed they should be underlaid with a layer of concrete to prevent their permeation with moisture from the soil. Further, the whole site, if necessary, may be covered with a layer of concrete 6 in. thick to prevent the entrance of ground air and moisture. As an alternative, the house may be raised on arches for the same purpose, allowing free communication with the outer air underneath the whole house. In any case, a sufficient space ventilated by air grates should be left between the basement and the soil ; otherwise, as soon as the air of the house becomes heated, an upward current is established, which has the effect

of drawing the ground air into the dwelling.

Cellars.—Storage cellars may exist in the basement, and the following points are to be noted regarding them. They should be dry, have a low temperature, and be free from ground air and ground water. The cement floorings should be underlaid with concrete, and the ceilings should be asphalted and air-tight, while there should be little or no communication with the interior of the house.

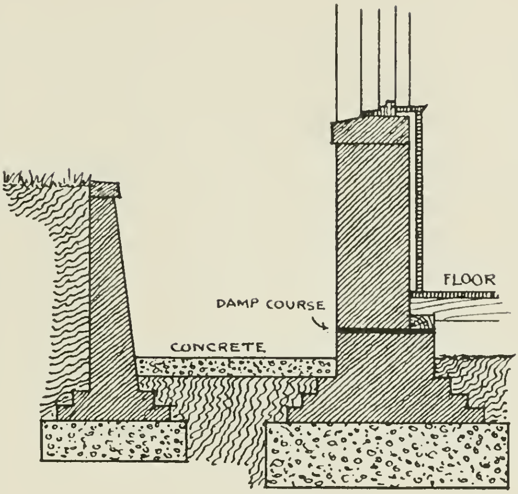


Fig. 81.—Dry area.

7. *Walls.*—*Footings.*—The walls, for purposes of stability, must be broadly based. These broad bases are called the footings (see Figs. 81 and 82), and rest upon the concrete foundations. In heavy or main walls they must extend on both sides of the wall, and must project on each side to a distance equal to one-half the thickness of the wall. From base to top the footing should be two-thirds the thickness of the wall at its base, and from side to side twice the thickness of the wall. The dimensions of the footings in any particular case depends on the nature of the foundations. In the case of brick footings, not more than one-fourth the length of each subjacent course should be free. It is most important that both footings and foundations be of the best material, as work is very apt to be scamped when hidden away underground. The same remark applies to the concealed part of the walls, which, further, should not be lined with wood.

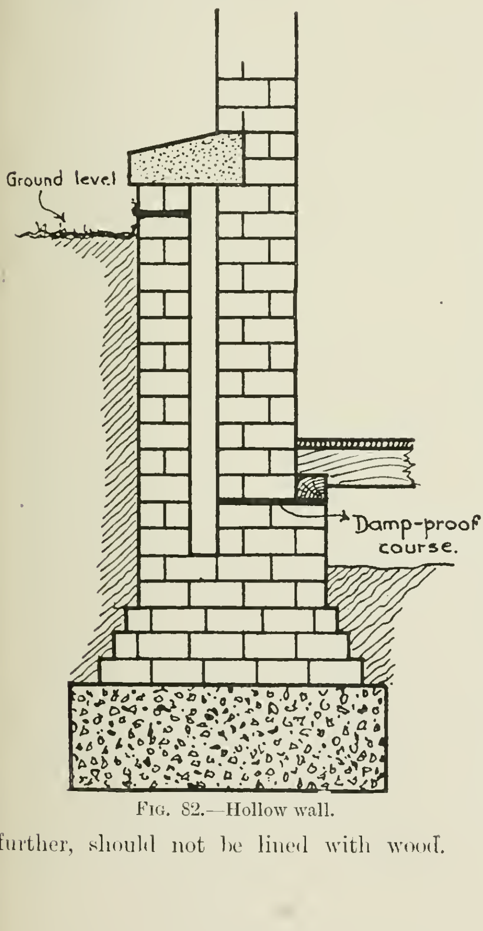


Fig. 82.—Hollow wall.

Damp-proof courses.—As water can rise in house walls by capillary attraction to a height of 32 ft., it is essential that moisture interceptors be placed in them. These are called damp-proof courses (see Figs. 81, 82, and 86), and may, in order of merit, consist of sheet lead, asphalt $\frac{3}{4}$ in. thick, Portland cement, glazed stoneware perforated longitudinally, and slates embedded in cement. As sheet lead is very expensive, the others are the most commonly employed materials. A convenient form is a layer of canvas impregnated with asphalt. One interceptor is required where the footing ends and the wall begins; a second, 6 in. above the level of the external earth; and as damp may enter the wall from above, a third on the very top beneath the roof timbers. The first must be below the lowest wood used in the building, the second is not required if the external earth is kept from coming in contact with the wall by the interposition of a dry area or air drain, as shown in Fig. 81. In any case it is advisable to coat the outer surface of the wall below ground with a layer of asphalt or of slates. Indeed, the whole dry area may be filled in with asphalt. As a substitute for the dry area, the hollow wall may be employed (Fig. 82). The space is terminated below by the lowest damp-proof course, or as seen in the diagram, and rises above the level of the ground. A second damp-proof course is inserted so that the outer portion of the wall, which is in contact with the ground, is entirely isolated by the damp-proof material and the hollow space, which must be ventilated. If only one damp-proof course is feasible, and there be no dry area, it should be placed in the second position, and, as before, should be beneath the lowest timber.

In the construction of walls, whether of stone or brick, the material is laid in layers or courses which are bound together by mortar or cement, are placed as nearly as possible at right angles to the stresses which have to be resisted, and should be laid perfectly level. Each course must be thoroughly moistened before another is superimposed upon it, in order to prevent too rapid absorption of moisture from the mortar or cement, thus interfering with its proper setting.

If of *stone*, the largest stones should be below, and those derived from the sedimentary rocks should be laid in their natural quarry beds to prevent weathering effects on their laminæ. Mortar should then be spread in a thick cream over the course, and worked well into the joints (grouting). The joints or vertical spaces between the stones should each be about $\frac{1}{8}$ in. in breadth, and those in adjacent courses should not coincide, but "break" to the extent of fully the depth of the course. The stones are laid in a course as "headers" or "stretchers," according as their long axes are at right angles or parallel to the course. There should be about three times as many stretchers as headers. Heavy work requires to be strengthened by the insertion of bonding-stones, which pass right through the wall from one side to the other.

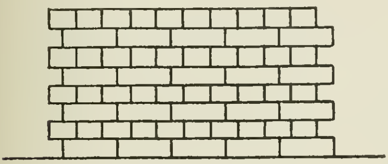
Styles of stone masonry.

(*a*) *Ashlar.*—Large blocks carefully dressed and laid, and used in heavy work. (*b*) *Block in course.*—A diminutive ashlar with less careful dressing. (*c*) *Coursed rubble.*—Irregular stones, but laid on their natural beds.	Courses all horizontal.

(*d*) *Common rubble.*—Irregular stones laid without definite courses.

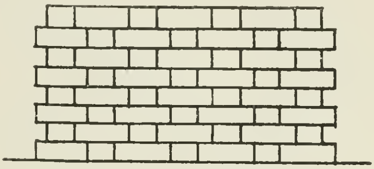
Coping-stones are placed on the top of walls, which they overhang and so protect from rain. A "string-course" or projecting part of the wall is used for the same purpose.

If of *brick*, only good sound bricks should be employed, and each brick should be dipped in water before being laid in its place, in order to clean it and to prevent it rapidly absorbing moisture from the mortar or cement. No joint should exceed $\frac{1}{4}$ in. in thickness, and each brick of the superior course should overlap the subjacent joint by at least a quarter of its length, and no



OLD ENGLISH BOND

Fig. 83.



FLEMISH BOND

Fig. 84.

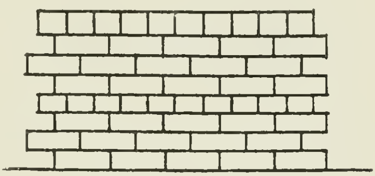
two vertical joints in adjacent courses should coincide. As in stone-work, there should be careful grouting of all joints. The bricks should bear a proportion of 5 to 1 to the binding material.

Like stones, bricks may be laid as headers or stretchers, and these may be arranged in divers ways, called bonding.

Alternate courses of stretches and headers constitute *old English bond* (Fig. 83).

Alternate stretchers and headers in a course form *Flemish bond* (Fig. 84).

Two or three courses of stretchers intervening between each course of headers is known as *Bastard bond* (Fig. 85).



BASTARD BOND

Fig. 85.

The old English is the strongest of these varieties.

In a wall only $4\frac{1}{2}$ in. thick all the bricks must be laid as stretchers. In thicker walls a choice of bonding is offered. Brick walls are frequently built double, in which case a space of 3 in. should intervene between the outer and the inner curtains, and the latter should be the thicker. The two curtains are usually bound together by special bonding bricks, or by galvanised iron clamps placed at suitable intervals (Fig. 86). Where a solid wall is required, the space between the curtains may be filled in with broken bricks, called closers and bats, which require very careful grouting. The whole structure is termed *Diagonal bond*.

The model by-laws of the Local Government Board lay down regulations as to the thickness of brick walls, which must increase with the length and height of the building. Outer house walls should in no case be less than 14 in. thick. Party walls may be $4\frac{1}{2}$ in. thick, if they be not more than 25 ft. high and are not separated by more than 30 ft. Brick walls are always thicker at the base than at the top.

If of *concrete*, which is not usually employed for houses, blocks of concrete are used, and much the same rules apply to them as to stone masonry. It may, however, be built in layers well punned down.

Wood may enter into the construction of walls, either combined with the other materials or by itself in the form of a double layer, the intervening space being filled with chalk or sawdust.

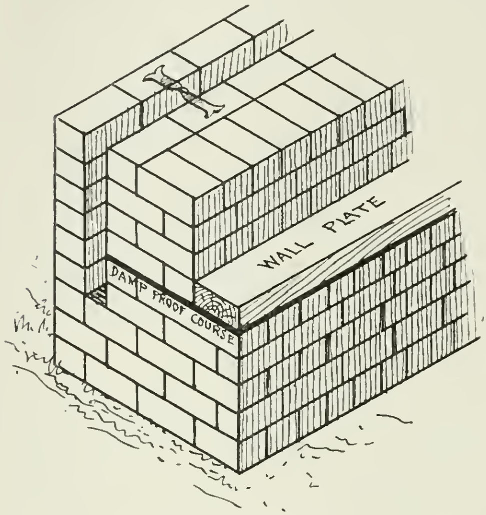


FIG. 86.—Double wall.

The inner or room walls of a house may be composed of brick, tiles, or of wood and plaster. The plaster is applied in three layers, from within outwards, the first containing sand and lime in equal parts mixed with ox-hair, the second being a cream of slaked lime with a little hair, while the third is a thinner and finer layer of lime and water. The plaster is usually covered with paper, which should be non-poisonous, varnished, and capable of being washed. Papers may advantageously be dispensed with, and a non-poisonous paint in the form of a silicate substituted for them.

8. *Chimneys.*—The flues should be straight, circular, separate one from the other, and smoothly lined, to prevent the risk of fires, to facilitate cleaning, and to aid the upward draught. All chimneys should rise at least 3 ft. above the roof.

9. *Roofs.*—A roof consists of two elements—(*a*) supporting, (*b*) covering. The former consist of the rafters, which in the simplest form of roof are only

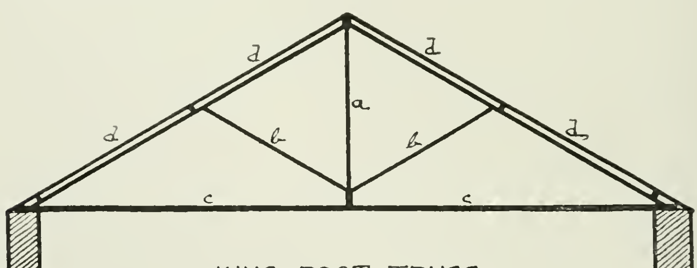


FIG. 87.—*a*, King post. *b*, Struts. *c*, Tie beam. *d*, Rafters.

bound together at the top. In more complicated forms, posts, ties, and struts are introduced to add strength (Figs. 87 and 88), and the rafter ends rest on pole-plates and ridge-plates. The rafters have to withstand their own weight and that of the covering material, along with the pressure exerted by wind and snow. The covering may be composed of slates, tiles, thatch, lead, copper, zinc, tin, or sheets of corrugated iron.

Slates are classed according to their size and quality, and are nailed with zinc, copper, or composite nails to boards which lie upon the rafters. A layer of felt may advantageously be placed between the boards and the slates, as

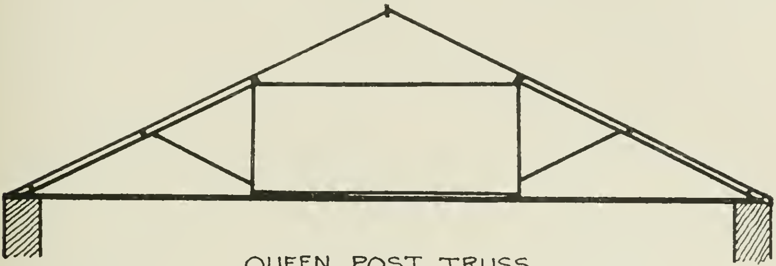


Fig. 88.

it tends to render a house cool in summer and warm in winter. The lap (Fig. 89) is the distance which one slate overlaps the next but one below it. It should never be less than 3 in., and varies with the steepness of the roof; the flatter the roof, the greater being the lap. A slate roof should be inclined to the horizon at 25° to 30°.

Tiles are fixed by oaken pins, and are not so good as slates; while thatch, though picturesque, is dirty, harbours birds and insects, and is apt to catch fire. Lead is the best material for flat roofs, zinc not being so durable; while copper and corrugated iron are unsuitable for dwelling-houses, which they render very hot in summer and cold in winter. The roof must protect the walls from rain, and for this purpose should project beyond them, or be furnished with rhones of lead or iron, which should discharge directly into the rain-water pipes, and should not be within the walls. Where a chimney or chimney-stack pierces the roof, water will enter, unless the stack or chimney be flanked and surrounded by a sheet of lead, constituting a "flash joint."

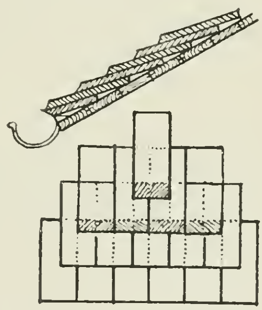


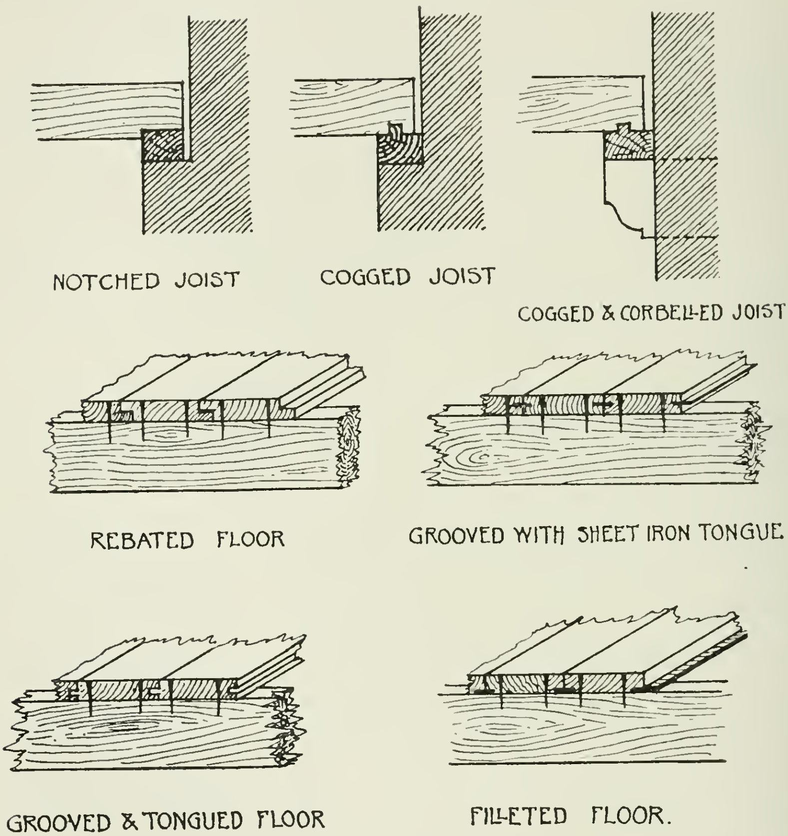
Fig. 89.

10. *Floors.*—Floors may consist of stone, brick, concrete, tiles, or wood. The last is the most frequently employed, and common deal is the form in general use, oak and teak, though excellent, being very expensive. As in a roof, there are two main elements in a wooden floor—(*a*) supporting,—joists, (*b*) covering,—boards.

(*a*) When the joists all run in one direction, they stretch across the breadth, not the length, of the floor. In strong floors, a secondary set of joists running at right angles to the first is introduced. The joists are connected with the walls by wall-plates, which are square blocks of wood resting upon the stone or brick of the wall, which may project, forming a corbel. The joists are connected with the wall-plates in various ways. Thus there is a notched joist, cogged joist, and a cogged and corbelled joist, as shown in Figs. 90, 91, 92.

Special ceiling joists may be present, to which the roof laths of the room below are fastened.

(*b*) Floor boards may merely be laid closely side by side and nailed on to the joists, or a more elaborate jointing of the boards by several devices may be employed, such as rebaiting, groove and tongue, fillet, dowel joints, etc. (Figs. 93, 94, 95, 96). Skirting boards hide the junction between floor and walls, and should be let into a groove on the floor.



Figs. 90 to 96.

11. *Ceilings.*—Ceiling laths may be nailed to the joists themselves or to the special ceiling joists, and ceilings are usually composed of wood and plaster. They may be whitewashed or painted, but should not be papered. Panelled wood alone may be used, but is expensive. The space between the ceiling and the floor above is usually filled with pugging or plasterers' rubbish to deaden sound. It harbours vermin, and is not fire-proof, while it may be a source of smells and nuisance. Slag-felt is much better, but in any case the space should be ventilated by Ellison's bricks (Fig. 97), or some such similar contrivance.

12. *Doors.*—A door frame is composed of a lintel, a sill, and jambs. The

door itself may be a very simple affair, or be considerably elaborated with bars and panels.

13. *Windows* consist of frames and sashes, and should be made to open top and bottom directly to the outer air. The size of windows should bear a definite relation to the size of rooms. There should be 1 square ft. of window area to every 100 to 125 cubic ft. of room area, or otherwise the windows should be equal in area to one-tenth of the floor space. If possible, the top of the window should be level with the ceiling. It is essential that the glass should be of good quality, so that ample light be admitted.

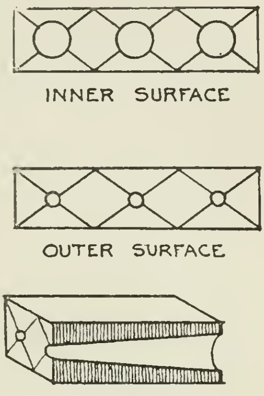


Fig. 97.—Ellison's Ventilating Bricks.

14. *Halls, Lobbies, and Staircases.*—Where at all possible, a house should be provided with a large hall and wide and lofty lobbies, which should not have abrupt turnings. Halls and lobbies should have direct connection with the external atmosphere, and are to be regarded as reservoirs and conduits for fresh air. Staircases are constructed in spaces called wells, and may be of wood, stone, concrete, or iron. They should be broad, not too steep, and the steps should be of a fair width. Steps have two parts, the tread and the riser. The former should be from 9 to 12 in., the latter from 5 to 7 in.

15. *Rooms.*—It is a common fault to build a house with fine reception-rooms at the expense of the bedrooms. A consideration of the length of time spent in each room will at once demonstrate the possibility of ill health arising from such a procedure, and emphasise the necessity of providing ample cubic space in the sleeping apartments. Every room should have a window opening

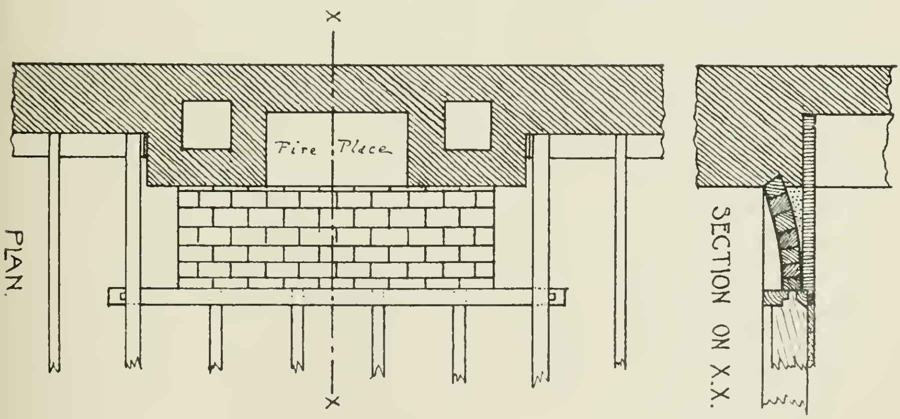


Fig. 98.

to the outer air, and be provided with a chimney flue. The height of rooms should not be less than 9 ft., and few rooms require to be higher than 12 ft.

16. *General Considerations.*—All internal woodwork should be painted and varnished, and plain or rounded surfaces should be the rule, as far as possible, in order to facilitate cleanliness and prevent the deposit of dust.

17. *Precaution against Fire.*—The sanitary outfit of a house is dealt with in another section, but the precautions necessary to obviate the risks of fire have now to be considered. A brick house is more secure than a stone one, as stones are apt to crack and splinter under intense heat. To be fire-proof, a floor must not be laid upon stone corbels, but should be built of concrete laid upon a fire-brick arch, supported by iron girders framed in concrete and cement. Measure's floor, as used in dwelling-houses, consists of flanged iron girders, between which concrete is filled in, and rests upon a basis formed of wood, iron, or tile stretching between the flanges. Instead of concrete, brick, fire-brick, or gypsum and broken brick may be utilised. Slag wool, as used in floors, is an excellent preventive, and a space should always intervene between floor boards and fireplaces (Fig. 98). No woodwork should approach within one foot of a stove. Staircases are better made of concrete than stone.

II. THE STRUCTURAL ARRANGEMENT OF HOUSES AND GROUPS OF HOUSES TO FORM A TOWN OR CITY.

In the olden days, capacities for defence against numerous foes largely settled the site of a town. At the present time, commerce, industries, education, and residential amenity are the main determining factors, and the opponents to be encountered are those pathogenetic microbes which wage interminable warfare against urban populations. The proximity of water, either fresh or salt, has much to do with the choice of situation; but though affording facilities in many directions and divers forms of benefit, water may bring with it attendant dangers, such as floating sewage and infected ships. As regards the geology of the site, it is impossible to limit the spread of a city by attention to the minor details which were considered in connection with a single building. A town must enlarge, and it must enlarge in continuity, notwithstanding the alterations in geological formation which it may encounter in its extension. Hence it is often necessary to undertake important works of drainage and sanitary engineering to render unhealthy areas inhabitable. If possible, a town should be placed above sea-level and sheltered from the colder winds. Further, it should be secured from floods, and be within easy access of a good water supply. Attention should be directed to the preservation of open spaces, especially of "lungs" scattered through the populous areas, and facilities should be afforded for a speedy, efficient, and, if possible, remunerative disposal of sewage and refuse. Streets should be wide, and cul-de-sacs unknown, so that free circulation of air may be obtained, while the presence of trees aids the purification of the atmosphere. A flat plain is undesirable, owing to the frequency of aerial stagnation and the great difficulties met with in getting rid of excreta, subsoil and storm waters. Thoroughfares should be so constructed as to be easily cleansed, and free in large measure from dust and noise. Roadways constructed of the proper kind of asphalt or of wood are the best. Industries causing danger or constituting nuisances to the inhabitants should not be permitted within the urban area. Atmospheric purity ought to be assisted by regulations as to smoke emission, and the health of towns would be improved if methods of heating involving less smoke production were in vogue.

The Local Government Board has laid down model by-laws regarding the level, width, construction, and sewerage of new streets, and the arrangement of houses. These will be found on p. 530.

It is essential that the evil practice of building back-to-back houses should be abolished, and such structures demolished wherever found.

III. VENTILATION, WARMING, COOLING, AND LIGHTING.

AIR INGRESS AND EGRESS.

Of the Individual Building.—Doors, windows, and chimneys form the usual channels by which air enters and leaves a building. These should be so placed as to secure diffusion of air currents throughout the room. Air also percolates into rooms through the materials of which the walls, ceilings, and floors are composed, but this channel is of small importance in ventilation if other inlets are available. Theoretically, fresh air should enter at the lowest point and leave at the highest. Practically, this is not desirable, as it causes chilling of the feet and floor draughts. There is little difficulty in comfortably ventilating a room when its temperature approximates to that of the outside air, all that is required being open windows and doors and a free passage up the chimneys. It is quite another matter when the room temperature is, as usually the case, considerably higher than that of the external atmosphere. The chill entering air impinges on the occupants and produces the disagreeable sensation of a draught.

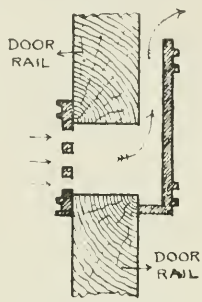


Fig. 99.—Currall's door ventilator.

Doors as Inlets.—They frequently act as inlets through being badly fitting, and air entering beneath a door causes a floor draught, usually passing from the door to the chimney. This should be prevented, and if the door is to act as an inlet, one of the upper panels may be removed, and a sloping piece of wood fixed in front of the aperture, or the panel itself may be hinged in such a way as to give the entering air an upward direction. One disadvantage of this method is that to a certain extent it does away with the privacy of the room. Currall's door ventilator enables the air to enter through a hole cut in the door, and it is given an upward direction by a metal plate fixed inside and projecting in front of, and above, the aperture. The outer aspect of the aperture is covered by a metal grating (Fig. 99).

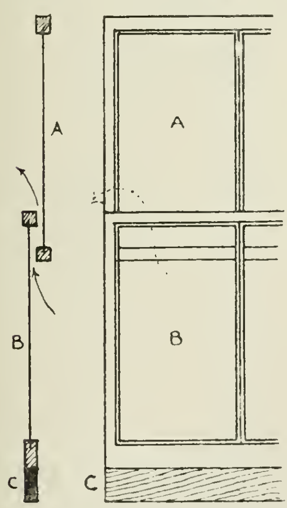


Fig. 100.—Hinckes-Bird's window ventilator.

Doors as Outlets.—Doors should only act as outlets when they communicate directly with the external air.

Windows as Inlets.—If no mechanical means of ventilation are employed, the windows should be opened from the top. In cold weather this will cause a draught, and it is better to introduce some simple method of securing adequate and comfortable ventilation.

(*a*) *Hinckes-Bird's method* (Fig. 100).—Here the inlet of air is between the two sashes, although the upper sash (A) is not disturbed. The lower sash (B) is raised, and the entering stream is deflected upwards by the upper part of the lower sash, passing into and diffusing through the air of the room. The entry of air beneath the lower sash is prevented by the introduction of a wooden board, (C) on which the lower rail rests, or which is placed on its inner side.

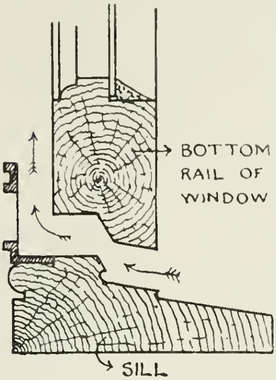


Fig. 101.—Currall's window ventilator.

(*b*) *Currall's window ventilator* (Fig. 101) consists of holes in the lower rail of the lower sash, through which the air enters, and from which it is directed upwards by a metal plate fixed in front of them.

(*c*) *Louvres.*—Movable louvres of glass may be substituted for one of the lower panes of the upper sash, and are opened and closed by a cord fastened to their metal frames, which must be kept clean and well oiled. Fixed louvres of glass, so arranged as to give the entering air an upward direction, constitute an alternative method, while the laths of a venetian blind in front of an ordinary open window may be so arranged as to do duty for louvres.

(*d*) *Cooper's ventilator* (Fig. 102).—A perforated circular disc may be fixed by an ivory point upon a window pane, in which apertures corresponding to those in the disc have been cut. The holes in the disc may thus, by rotation of the disc, be brought opposite those in the window. This has the advantage that there can be no rushing, but, on the other hand, the air enters without any upward deflection.

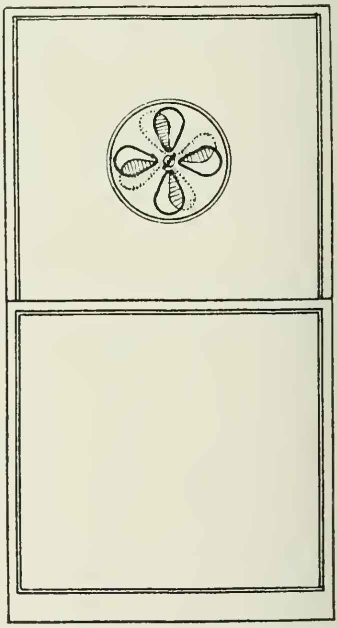


Fig. 102.—Cooper's window ventilator.

(*e*) *Windows on pivots and movable sashes or panes* opening inwards may be employed.

(*f*) *Double windows.*—In this case the outer window below and the inner window above are opened as a means of ventilation.

Windows as Outlets. — Apertures created by any of these methods may act as outlets under certain conditions, depending on air temperature and the size and number of openings which may act as inlets.

Chimneys as Inlets. — A chimney should not act as an inlet, as, in addition to air, there may be an entry of wind, smoke, soot, rain, snow, and possibly feathered inmates, such as jackdaws or starlings. They act as inlets when the ordinary ascending currents in them become so far cooled as to become heavier than the air in the room. Gales of wind may drive down a chimney if it be wide or so placed in relation to adjoining structures as to become a shoot for downward deflected currents. For this amongst other reasons chimneys should not be overlooked by neighbouring buildings. A conical cap or a fixed cowl may be attached to the top of a chimney to prevent its acting as an inlet.

Chimneys as Outlets.—Chimneys are the main outlets of an ordinary house. This is due to the aspirating action of wind blowing across their open tops, and to the heating of the air column by the fire below. They should never be blocked so as to interfere with their outlet action. Mechanical appliances may be adjusted to chimneys so as to increase their powers of extraction. Thus a long iron or tile pipe may be fixed on to the chimney-top to increase the length of the whole shaft, and enable it to open at a higher level. Cowls, whether revolving or fixed, have not been proved to supplement the mere aspirating action of the wind, but they keep out rain, which, by cooling the column of air, interferes with the proper outlet action.

Artificial Openings.—*Inlets.*—An inlet should neither be too high nor too low in the wall. If too high, the incoming air strikes the ceiling and a down-draught is produced, impinging on the heads of the occupants. If too low, a floor draught results, chilling to the feet, and trying to the temper. The best position is at a height of from 5 to 6 ft. above the floor level, and the inlet should be so shaped that a spray of fresh air mixes freely with the hotter air of the room, and no draught is forthcoming.

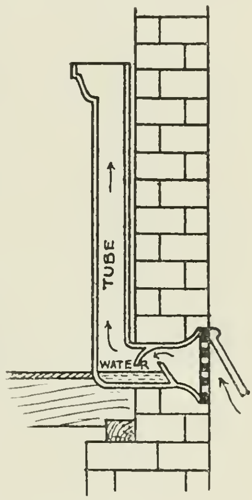


Fig. 103.—Tobin's tube.

This is best secured by a *Tobin's tube* (Fig. 103) with a funnel-shaped exit and an entrance from the outer air larger than the calibre of the tube itself, and screened by a grating. The amount of air entering can be regulated by a hinged plate, which can occlude the grating to any extent required. Cleansing of the air admitted may be effected by the introduction of a little water pool or a gauze diaphragm, but inasmuch as these require attention, they are of doubtful practical value. The best device of this nature is a conical muslin bag stretched on wire with its apex downwards. It can easily be removed and cleaned, though this essential precaution is liable to be forgotten. In hot weather, lumps of ice may be placed in the tube to cool the entering air, which, conversely, may be heated in winter by a gas jet placed under the tube where it turns upwards after coming through the wall. The exit should also be screened. Ere this we have observed hats, carefully laid upon the gaping inner end of a Tobin's tube, promptly disappear, to the amazement of the hapless owners unversed in ventilating apparatus! The mean calibre of the tube should be between 6 and 12 in. in diameter, and the tube itself should be curved, and not bent at right angles, where it passes from the wall into the room. It is usually made of wood, and the exit should be from 5 to 6 ft. above floor level, as the draught shoots the air spray another foot or two upwards after leaving the tube. This spray should have a free exit and not strike against an overhanging shelf or projection of any kind. Tobin's tubes are apt to get dirty and clogged, so that the gratings should be removable for the purpose of frequent cleaning.

Sheringham's valve (Fig. 104) consists of a metal box fixed either in the outer wall or in a wall bounding a hall or passage. It has a metal flap, projecting into the room, which can be closed or opened as required. The internal opening has an area of 27 in., which is somewhat larger than the outside area, and so diminishes the velocity of the entering stream. The valve should not be placed too near the ceiling.

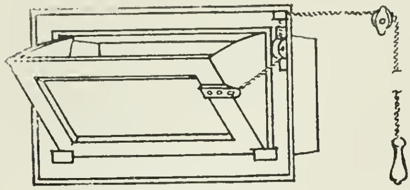


Fig. 104.—Sheringham's valve.

Steven's drawer ventilator (Fig. 105).—This is like a drawer without a back inserted in the wall, and when it is open the air enters the room vertically through apertures in the upper side of the drawer, each of which communicates with a compartment bounded by metal plates, which break up the entering current.

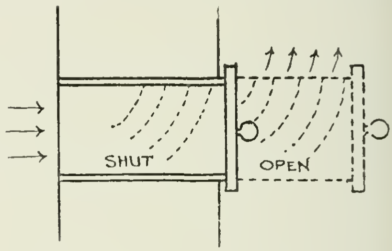


Fig. 105.—Steven's drawer ventilator.

Jenning's inlet (Fig. 106).—The air passes first into a dust chamber, and thence through louvres it is directed upwards into the room. It is usually built of brick.

Ellison's air bricks are perforated bricks with small external and large internal openings, the passage for the air being thus conical in shape (Fig. 97).

Perforated skirting boards connected with the outside air by Jenning's inlets or Ellison's bricks are also in vogue, but unless the air is previously warmed it should not enter the room at such a low level.

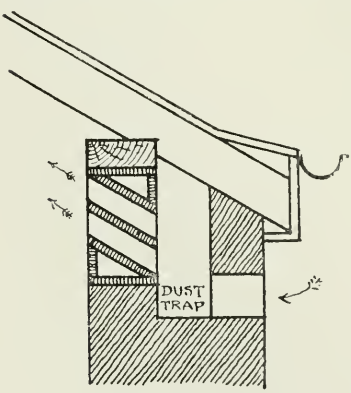


Fig. 106.—Jenning's air bricks.

Ventilating grates and stoves are varieties of inlet combined with warming, which are discussed on p. 327.

Outlets.—Any of the inlets mentioned may upon occasion act as outlets. Special devices for extraction are seen in shafts surrounding chimney flues, in which an upward current is maintained by virtue of the heat in the chimney. Such shafts should have their internal openings near the top of the room. Openings are sometimes made high up in the room wall into the chimney flue, and are protected by valves so as to allow exit of air into the shaft without any corresponding inward current. These valves may be made of mica (Boyle's) or metal (Arnot's), but the whole method is undesirable, as too much reliance is placed on the mechanical action of the valves.

A single straight shaft may be used to remove the vitiated air from a room, and its action may be supplemented by a gas jet. If the air be not artificially warmed, outlets should be at the top of the room; if warmed, they may be anywhere in the walls. They should be straight, circular, and smooth internally. If there are a number of outlets they should all be at a similar height from the floor, and all be equally exposed to sun or wind, otherwise the functions of some of them will become inverted. A small fan, driven or controlled by a water jet impinging on its vanes, acts as an excellent extractor, especially when combined with the Tobin system of inlet.

Inlets and Outlets combined.—*Mackinnell's ventilator* (Fig. 107) is the best method. It consists of a double circular tube, an inner outlet, and an outer inlet. The outlet or inner tube rises above the inlet or outer tube, and is protected above by a cowl or cover. The outer cylinder should have a free area equal to, or larger than, that of the inner cylinder, and the air entering by it should be spread out at the foot by a circular flange fixed to the lower end of the latter. Gas jets attached to the lower surface of this flange aid the extractive power of the inner shaft.

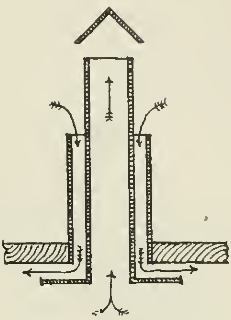


Fig. 107.—Mackinnell's ventilator.

Single tube.—This is a rudimentary form of the above, in which a single tube is divided into two by a partition, one-half acting as an inlet and the other as an outlet.

Ventilating cornices are on a similar principle, and though of various varieties are not specially advantageous.

Ventilating grates and stoves acting both as inlets and outlets are discussed on p. 327.

Relative Size of Inlets and Outlets.—The outlets should be a little larger than the inlets, as heated air has a slightly greater volume than the same quantity of cold air. The change, however, is but trifling. There should be 24 square in. of inlet or outlet for each occupant of a room, and it is better to have a number of small inlets at different points, but it is a disadvantage to divide up the outlets in a similar manner. One inlet may serve two or three persons, being 48 to 60 square in.; one outlet six persons, being 1 square ft. in magnitude.

Shape of Inlets.—There is an advantage in making the inner ends of inlets either conical or trumpet-shaped, as this facilitates the mixing of entering air with that in the room.

VENTILATION ON A MORE EXTENSIVE SCALE AS APPLICABLE TO TOWNS, LARGE BUILDINGS, MINES, TUNNELS, AND SHIPS.

Towns.—As already stated, there should be ample open space, and the buildings should not be placed so as to obstruct free circulation of air through the streets, while the site, if possible, should be such as to favour efficient wind purgation. The effect of thunderstorms upon the vitiated air of towns is often sudden and remarkable, and a method may yet be devised whereby electricity may be used for purifying air on a large scale.

Large Buildings.—The ventilation of such places cannot always be left to natural processes aided by the various methods which have been described. In many instances, if the building be not too large, or devised for special purposes, some of these answer admirably. Thus a combination of Tobin's tubes and Mackinnell's ventilator supplemented by a sunlight is an admirable way of ventilating a hall. A sunlight is an arrangement of gas jets around the foot of an outlet shaft. In many large buildings, such as concert halls, theatres, and churches, the acoustics are of primary importance, and must not be interfered with by the ventilating apparatus.

The ventilation of large buildings is best managed by artificial means.

1. The air, to ensure its being fresh, should be drawn from a considerable distance away from the building. This is done by long shafts passing into a storage chamber. Along these the fresh air passes, just as in the case of a Tobin's tube. The natural movement, which is a process of suction, may be supplemented by heat or fans. In the chamber it is filtered through gauze, cotton-wool, or coke, spread out on frames washed by water sprays, and then, having been cooled or warmed as desired, it is ready for the second part of the process. (See Figs. 184, 185, and 186, pp. 412 and 413).

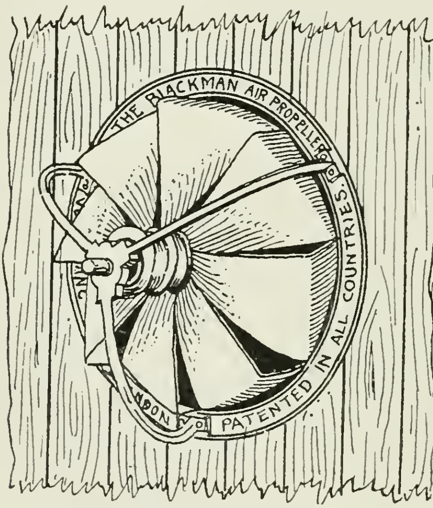


Fig. 108.—Blackman's fan.

2. *Propulsion.*—The air thus prepared is propelled into the area to be ventilated by powerful revolving fans, which can send it in any direction and with any force required, and further, can regulate the amount supplied.

3. *Extraction.*—The air, when vitiated, is removed by shafts, currents being maintained in them by aid of heat, steam jets, or fans similar to those used in propulsion.

Heat.—Sunlights may be employed, or shafts round chimney flues, or shafts leading to a furnace at the foot of a tall chimney. In place of a furnace, metal coils containing steam or hot water may be used.

Steam jets.—A method useful where there is spare steam. The jet is blown forcibly into a chimney, and, by a process similar to that of aspiration, induces a strong, upward current.

Fans.—The best known, in the case of buildings, is Blackman's Air Propeller (Fig. 108), which consists of a circular revolving wheel with metal vanes fixed to the spokes. The same fan may be used as an extractor or propeller, according as it is placed at an outlet or an inlet, and according to the way in which it is turned. The amount of air removed or supplied depends on the rate at which the fan is driven and the size of its vanes. These fans can be driven by steam, gas, electricity, or water power.

Mines and Tunnels.—The methods employed are simple shafts, or shafts combined with artificial acceleration of air, such as heat, steam jets, pumps, and fans.

(*a*) Simple shafts are single or double, but in any case there must be an upcast and a downcast, acting respectively as outlet and inlet. The fresh air is directed along the mine galleries by means of double doors and partitions.

(*b*) *Heat.*—In its simplest form heat is utilised by means of an open fire or furnace placed at the foot of the upcast shaft, with the primary object of producing rapid and efficient removal, which is necessarily followed by a suction action on the air in the downcast shaft. In a "fiery" mine the air used for furnace fuel combustion must be derived directly from the outer atmosphere, to obviate the danger of the mine air coming in contact with the flame.

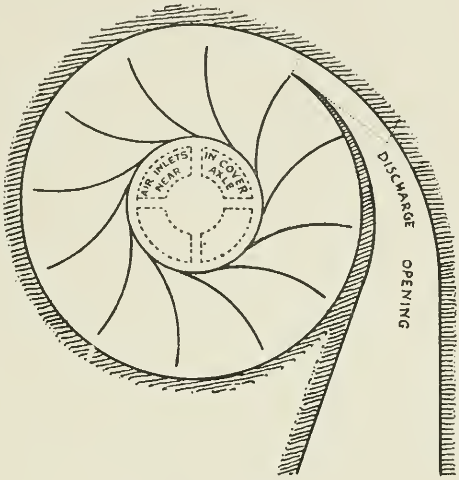


Fig. 109.—Guibal's fan.

(*c*) *Steam jets.*—They play into vertical pipes, fitted to a frame on the top of the upcast shaft.

(*d*) *Pumps.*—These are a combination of air and water pumps, with such an arrangement of valves that the air is expelled from the pump when the water is admitted, and admitted from the mine when the water is expelled. It is thus seen to be an extraction method.

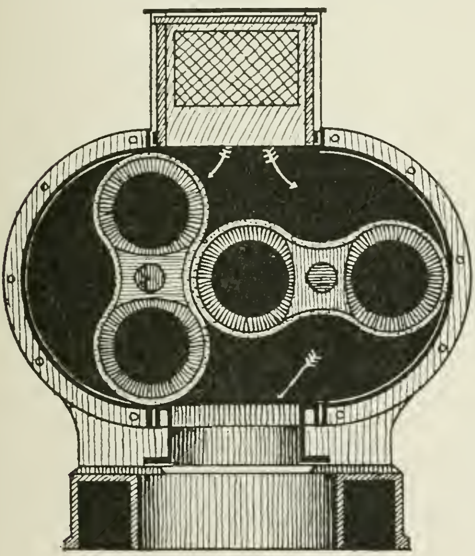


Fig. 110.—Root's blower.

(*e*) *Fans.*—Various forms are used in mines, Guibal's fan being an excellent example (Fig. 109). It consists of a series of steel vanes attached to a central axle, through an opening in which the fresh air is admitted. They revolve in a circular chamber, which communicates at its periphery with a channel, along which the air, set in motion centrifugally by the vanes, is driven rapidly.

Root's blower (Fig. 110) is another form, composed of a box, closed save for an aperture of entrance and one of exit. In this box two dumb-bell-shaped metal pistons, placed on parallel axes, rotate at right angles to each other, thus setting the fresh air in motion and expelling it in quantities proportional to the rate of rotation. For tunnels, fans are by far the best method.

Ships.—The ventilation of ships is a complex problem which cannot be said to have been properly solved. Large vessels require to be artificially ventilated, by means of shafts surrounding the funnels, fans, steam jets, and hot water, or steam coils. In addition, the natural methods in use on smaller ships are called into play, and aided by port-holes and scoops, windmills and trysails, hatches, fixed metal tubes, and hollow masts. The fixed ventilators have revolving cowls, turned by a vane towards the wind, thus keeping the bell-shaped mouth of the tube constantly facing the air current. If designed for extraction only, they act by aspiration.

WARMING.

Of Individual Building.—This is accomplished by open fires; stoves; hot air; water; or steam pipes; and by electric heaters.

Heat may be transmitted by conduction, convection, or radiation.

Conduction is the method whereby heat passes directly by contact, either from the hotter to the colder parts of the same body, or from a hotter to a colder body.

Convection is the conveyance of heat by heated air, or other particles, passing from one place to another.

Radiation.—Heat is said to be radiated when it passes from one point to another, without raising the temperature of the medium through which it travels. It passes through the medium in straight lines of radiant energy, which are transformed into heat on reaching the object. The amount of heat received by the object varies inversely as the square of the distance of the object from the source of the heat.

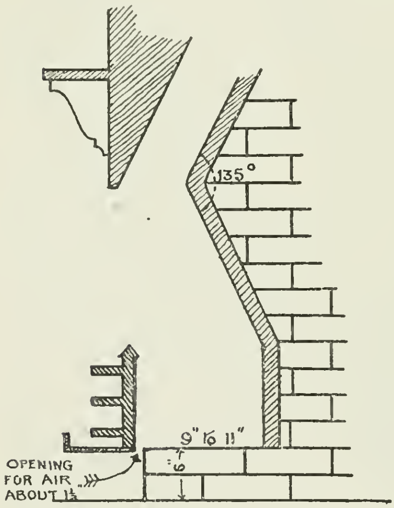


Fig. 111.—Hygienic fireplace.

(*a*) Open Fires.—*Construction of a fireplace and grate* (Fig. 111).—The space already described as being left in the floor, around and at the sides of the fireplace, has to be filled up with incombustible material, such as a hearth-stone, or bricks set in cement, or cement alone. Tiles may be used as a covering and decorative addition.

1. The back, base, and sides of the fireplace should be constructed of fire-brick, and should be solid.

2. The solid base of the fireplace should be about 6 in. in depth, *i.e.* the part on which the fuel has to rest should be this distance above floor level. Its length from before backwards should be from 9 to 11 in.

3. The vertical sides should converge towards the back, which is thus rendered narrower than the open front.

4. The back should overhang the fuel cavity, so that the throat of the chimney is narrowed and the base of the fuel cavity wider than the top. The chimney flue and the fireplace should, in this way, be inclined towards each other at an angle of 135°.

5. All fire-bricks should be lined with fire-clay.

6. The fuel should rest directly on the fire-clay forming the base, no iron bars intervening.

7. The front bars should be movable, narrow, vertical, and far enough apart to just admit a poker.

8. Air is to be admitted through a horizontal space, 1 to $1\frac{1}{2}$ in. in depth beneath the bars, and this space can be closed at will by a shield.

Such is an ideal form of fireplace which favours complete combustion, while there is less loss of heat than in any other form. The fireplace of the Teale pattern is of this nature, but there are no front bars, the fire burns in a hollow or well, and the air is admitted beneath a raised hearth. The iron grates in common use are dirty, wasteful, inefficient, and unsightly. Grates made of combined fire-clay and iron are of intermediate value.

(*b*) Stoves.—*Materials* of which they are composed.—Bricks or tiles, cast or sheet iron.

Advantages.—1. More uniform warming of the room, the hot stove walls drawing cold air to them and warming it, after which it ascends towards the ceiling, and circulates through the apartment.

2. There is less loss of heat, there being a greater radiating surface, and less extraction of warm air as compared with the open fire.

3. Economy in fuel consumption.

Disadvantages.—1. They do not act as such efficient ventilators as open fires.

2. They diminish the relative humidity of the air. This, however, may be combated by the proximity of a vessel containing water.

3. If the walls of the stove get very hot, and especially if they are composed of metal, there is a nuisance produced by the smell of scorched organic matter in the air.

4. Further, carbon monoxide may be formed in the stove owing to imperfect combustion, and pass into the room owing to bad jointing and the permeability of hot metal.

Carbonic acid, the product of combustion, in passing through the heated iron, may be converted into carbon monoxide, or the atmospheric carbonic acid coming in contact with the hot external surface may undergo a similar transformation. Coal or gas may be used as fuel, but in every case a stove must be provided with a flue, by which the products of combustion may be removed from the house. This does not hold in the case of oil stoves if there is efficient ventilation and complete combustion of the hydrocarbons. The latter will be the case, provided good oil is used. Oil stoves should have a diffuser or radiator placed above them to increase their action.

(*c*) Hot Air.—In this method the air conveying the heat is conducted from a central heating chamber to the rooms by means of pipes. In the chamber the air is heated either by being made to circulate through pipes placed in a fire, or by coming in contact with the external surface of pipes which contain smoke and hot gases derived from a fire.

(*d*) Hot Water.—The use of water for conveying warmth depends on the high specific heat which water possesses, and thus the heat contained by a small quantity of water can raise the temperature of a large quantity of air. There are two hot-water systems—(1) The low pressure; the water is not heated above 100° C. (2) The high pressure; the water is heated to a temperature of from 120° to 160° C.

1. In this system a boiler and distributing pipes are required, and the boiler must possess sufficient power and heating surface. The boiler power is the number of square feet of pipe surface which the boiler will efficiently heat for each square foot of its own surface. The boiler is usually placed in the basement. The pipes are of cast-iron, having diameters of 2 or 4 in., and the water circulates from the boiler through the pipes and back to the boiler again. The pressure exerted is $23\frac{1}{2}$ in. of mercury, or 12 lb. per square inch. There is a single efferent pipe which divides into branches, reaching, if required, to every part of the house. The efferent pipe springs from the upper part of the boiler, because the hot water, being lighter, tends to rise. It does so even unto the topmost pipes, where it becomes cooled and promptly descends. All the return pipes reunite into a single efferent trunk, which reaches the boiler at its bottom. The area of pipe surface required for heating any room, and stated in square feet, is equal to

$$\frac{\text{The heat required (in degrees Fahr.)} \times \text{the cubic contents of the room in cubic ft.}}{\text{The time in minutes in which the effect is to be produced} \times 190}$$

It is customary to add ·026 of a square foot of pipe for every foot of glass and wall surface to be heated.

A safety pipe is necessary, passing from the highest point in the circuit to the outside air and discharging usually on the roof, thus permitting the escape of air and steam. The pipes may be aggregated to form a radiator.

2. This is Perkin's method, in which no boiler is required, the pipes themselves, in the form of a coil, passing through the furnace fire. One-tenth part of the piping is in the fire ; the rest forms the circuit. These pipes are of wrought-iron, and are $\frac{1}{2}$ to 1 in. in internal diameter. Tremendous pressure alone prevents water at such high temperatures vaporising as steam. Thus water at 120° C. requires to be subjected to a pressure of 137 in. of mercury or 68 lb., and at 160° C. to 250 lb., per square inch. No escape pipe is provided, but at the highest point in the house reached by the pipes, the latter are expanded, and here contain a little air as well as water to permit a slight expansion of the water and obviate the risk of bursting. This system is not so suitable for dwelling-houses as for larger buildings, because it tends to overheat the air. As in the low pressure system, the pipes may be aggregated to form a radiator. Less pipe surface is required in this system than in the low pressure system, but it is impossible to have valves cutting off portions of the system, which is also somewhat complex and liable to freeze in winter when not in use.

(*e*) Steam.—Steam forms a valuable heating agent, on account of the large quantity of latent heat it possesses, and which is given off when it condenses into water. A boiler and narrow pipes of wrought-iron are required. The latter convey the steam, and are covered with felt to avoid condensation in transit. They open into condensing pipes of copper or cast-iron four times their size, from which the condensed water returns to the boiler. A safety valve is necessary. This method is also more applicable to large buildings than to dwelling-houses.

(*f*) Electric Heaters consist of electric heat lamps aggregated together and placed in front of a copper fan or background. The electrical energy is converted into heat, and partly into light, by being passed through wires considerably thicker than those employed in incandescent electric lamps. They act both by radiation and convection, are clean, do not foul the air, and the heat is obtained immediately.

Of Towns.—Our present British method of coal-fire warming is wasteful in fuel, and the smoke discharge from the multitudinous house and factory fires renders towns unhealthy by reason of dust and fog. Sunlight is excluded, urban vegetation stunted, street accidents invited, and tempers spoiled, by the ungenial presence of the great smoke fiend (see p. 302).

WARMING AND VENTILATION COMBINED.

Under this heading fall to be mentioned those methods which have for their purpose the warming of the fresh air supplied.

(*a*) Open Fires.—In their case this is accomplished by means of an air space at the back of the fuel cavity, communicating on the one hand with a fresh air current, and on the other with the air of the room. Galton's ventilating fireplace is a good example (Fig. 112). In it the entering air passes over the heated back portion of the fireplace, and is directed up a special

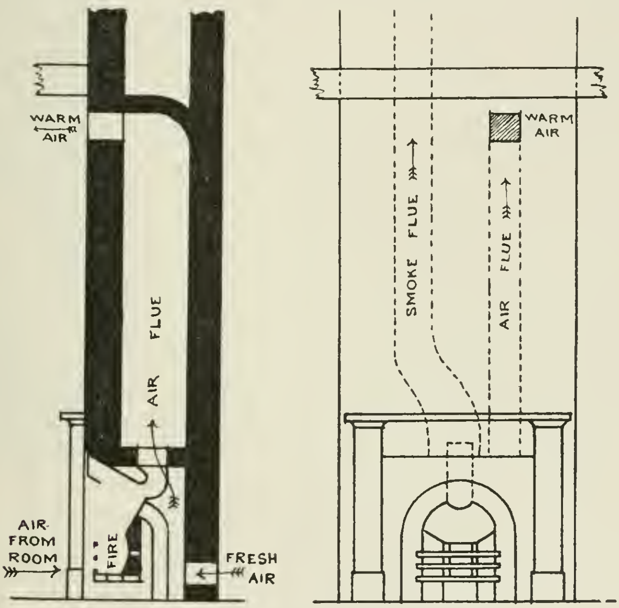


Fig. 112.—Galton's ventilating fireplace.

shaft which opens into the room near the ceiling. The shaft should not be of iron, otherwise there will be a risk of carbon monoxide being formed. Such a method should not be applied to ordinary fireplaces and grates, as the jointings are often defective, and through them foul air from the chimney flue is apt to find its way into the room. There are numerous contrivances all on the same principle, but differing somewhat in construction and in the situation of the outlet into the room, which in Galton's method is placed too near the ceiling.

(*b*) Stoves.—Pipes conveying the fresh air supply may be made to pass through stoves, as in the case of George's calorigen and the Euthermic stoves (Fig. 113). These are both gas stoves, and act well.

Another device is to make the fresh air pass over and between iron pipes containing hot water, connected with a small boiler situated at the back of the fuel cavity of the stove. In the Euthermic stove the air necessary for combustion is drawn from the room itself, and this is a desirable source, as such a procedure aids the air circulation in the room.

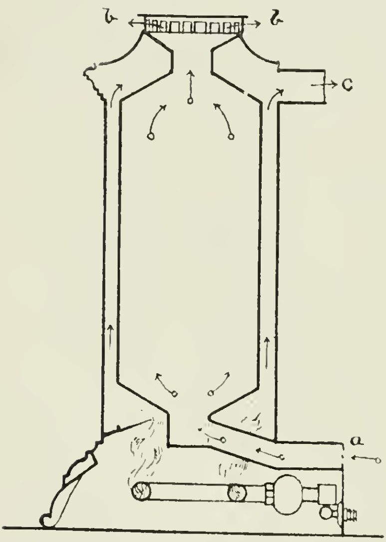


Fig. 113. — Euthermic stove (Bond's). *a*, Fresh air inlet. *b*, Warm air inlet to room. *c*, Combustion products outlet.

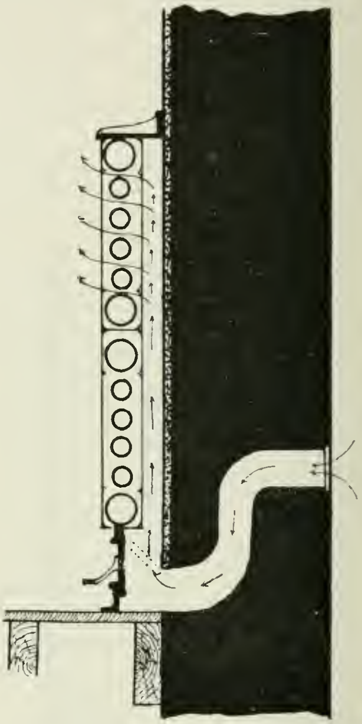


Fig. 114.—Ventilating radiator in section.

(*c*) Hot Air.—The method of warming by hot air necessarily implies ventilation, provided the air contained in the pipes, or passing over them, be derived from without the building.

(*d*) Hot Water.—In the case of the low pressure system, fresh air is passed through the aggregation of hot water pipes known as the radiator (Fig. 114).

(*e*) Steam.—Here also fresh air passed over the hot steam pipes affords a convenient method of combining warming with ventilation.

No heating pipes or radiators should be so cased or screened as to allow the accumulation of dust around them.

COOLING.

In hot countries, and even at rare intervals in this country, the question of how to cool a house and keep it cool is important. A simple way of doing so is to shield it from the sun's rays by trees, verandahs, jalousies, blinds, and shutters. If the air is dry, it is cooled by moistening, which is effected by letting it pass over wet surfaces of various kinds, or subjecting it to water sprays, or bringing it into contact with blocks of ice. On a larger scale, air can be cooled by bringing into contact with it compressed air, which is allowed to suddenly expand by the pressure upon it being removed. Evaporation is accompanied by absorption of heat, hence if a volatile liquid be rapidly evaporated the air in its neighbourhood can be cooled .

COOLING AND VENTILATION COMBINED.

This is usually effected by passing the fresh air through a water spray, water bath, or ice chamber.

LIGHTING.

The agents employed are sunlight, candles, oil, coal gas, and electricity.

Sunlight is essential for health, and no room should be without its cheering rays. It promotes human growth, and prevents germ growth. No house is healthy unless sunlight has access to each room. The larder, the wine cellar, and the situation of the cistern alone form exceptions to this rule.

Candles.—These are made of tallow, wax, spermaceti, or stearin, and provided with wicks. As an elementary form of light, candlelight is used as the standard for artificial illuminating power. "One candle power" is the light produced by the combustion of a sperm candle burning at the rate of 120 grs. per hour. This is the unit of light. The products of combustion are water vapour and carbonic acid, and two sperm candles foul as much air as one man. They are comparatively feeble illuminants, but in themselves produce little or no ill effects on the health.

Oil.—The chief illuminating oil is paraffin, and it is burned in lamps by means of wicks. It consumes the oxygen of the air to a greater extent than candles, and gives off water vapour and carbonic acid. A good oil lamp of moderate size is equivalent to several men in its power of rendering the air impure. Per weight, paraffin oil is said to be twice as powerful an illuminant as candles. Inferior oils have low flash points, and are consequently dangerous, being liable to ignite and cause fire.

Coal Gas is still the most widely used illuminant, though it possesses many disadvantages, being poisonous and explosive, while in use it renders the air impure. It is, however, cheap and fairly powerful as a lighting agent. Coal gas is a purified product of the destructive distillation of coal, and consists of—

(*a*) *Diluents.*—Hydrogen, marsh gas, and carbon monoxide, 90 per cent. by volume.

(*b*) *Illuminants.*—Olefiant gas, acetylene, and benzene, 6 per cent. by volume.

(*c*) *Impurities.*—Nitrogen, carbonic acid, and traces of sulphur compounds, 4 per cent. by volume. Sulphuretted hydrogen ought to be completely absent.

The products of combustion are water vapour, carbon dioxide, carbon monoxide, ammonia compounds, sulphurous acid, and other sulphur compounds. Theoretically, each gas burner should have a special outlet for its combustion products. Practically, provision must be made for each gas-lighted room having sufficient outlet. One gas jet fouls as much air as five or six men, but much depends on the burner employed. Thus the introduction of the Welsbach or incandescent burner renders the light more brilliant for a smaller consumption of gas, and consequently for a less production of impurity. In addition, it does not use up so much oxygen, and produces less heat. The light is given out by a gauze mantle, composed of the oxides of various earths, raised to a high temperature in a Bunsen flame, and in fouling power one incandescent light is equal to about three men.

The subjoined table, compiled from tables published in the *Lancet* of January 1895, shows the comparison between different forms of lighting in various respects :—

Burners.	Consumption of Cub. Ft. of Gas per Hour.	Cub. Ft. of Carbonic Acid evolved per Hour.	Number of Human Adults producing the same amount of CO_2 per Hour.	Candle Power per Cub. Ft. of Gas consumed per Hour.	Increased Temperature (F.) per Candle Power.
Welsbach without mantle	3·5	1·82	3·03	15	·116°
Argand . .	6·0	3·12	5·20	3·16	·590°
Batswing . .	6·0	3·12	5·20	1·6	·807°
Oil lamp (16 candle power)	2·08 oz. oil per hour.	2·91	4·85	...	·468°

The table is based on the following data :—
One cubic ft. of coal gas yields ·52 cubic ft. of CO_2.
One adult exhales ·6 of a cubic ft. of CO_2 per hour.

Water Gas is made by passing a current of steam through incandescent carbon, and then, in order to secure luminosity, enriching it with petroleum or naphtha. Its use as an illuminant in houses is contra-indicated, because it contains a large quantity of carbon monoxide and is poisonous, so that any leakage is dangerous. Wherever used it ought to be "odorised," as it possesses no smell.

Acetylene Gas (C_2H_2).—Acetylene is a hydro-carbon and one of the illuminants of coal gas. It can be used alone as a lighting agent, being evolved when water comes in contact with carbide of calcium. The latter is prepared from a mixture of lime and carbon by the action of very high temperatures produced by electricity—

$$CaO + 3C = CaC_2 + CO, \text{ and } CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2.$$

It is colourless, has a strong odour, and can be stored in gasometers or burned in special lamps. It easily explodes when mixed with air in a proportion of 7 per cent., but is only very slightly toxic. For household use improved apparatus for its combustion is required, as at present lamps have to be recharged with carbide daily, a process both difficult and offensive.

Electricity.—From a hygienic point of view, electric light is the best, as it has none of the disadvantages of the other forms of lighting. It does not vitiate the air, deprive it of oxygen, nor yield to it carbonic acid, watery vapour, or much heat, while it is clean, and does not discolour walls or ceilings. It may be necessary to moderate the intensity of the light, which is often trying to the eyesight. An electrically lighted town is, cæteris paribus, a more hygienic town than one lit with gas, since a large consumption of gas contributes to the production of foul air and fog.

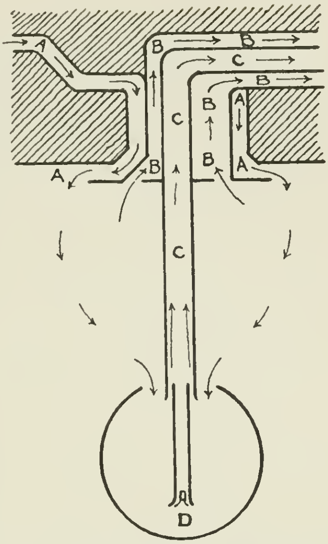


Fig. 115.—Ventilating globe light. *a*, Fresh air inlet. *b*, Exit of foul air from room. *c*, Combustion product outlet. *d*, Burner.

LIGHTING AND VENTILATION COMBINED.

As already seen, gas light may be advantageously employed to assist extraction in the form of a sunlight, etc. This method, in the form of the ventilating globe light (Fig. 115), is well adapted to dwelling-rooms. Candles and oil lamps are feeble aids to ventilation, produce much heat, and so require that allowance be made for them in the ventilation of a room in which they are employed.

IV. THE COLLECTION AND DISTRIBUTION OF A PURE WATER SUPPLY.

OF INDIVIDUAL BUILDING.

A single house may derive its water from (A) a private, or (B) a public source. If the former, rain, wells, springs, rivers, and streams, ponds or lakes, may form the supply.

A. (*a*) *Rain.*—A house deriving its water supply from rain must have a collecting surface, means of transit, and methods for storage, filtration, and distribution.

1. *Collecting surface.*—This should be clean so as not to contaminate the water, and should yield nothing injurious to the water. Further, it should be impervious, easily accessible, easily cleaned, and so placed that the water may reach the house by gravitation. The following materials are in common use, slates, tiles, stone slabs, stone or iron tanks, concrete, cement, and corrugated iron or zinc. The roof is frequently adapted for a collecting area, but if so used there must be no lead in it, and as far as possible it should not be subject to the deposit of soot and dust upon it. The quantity of water so collected is of necessity limited, and it has been estimated that only about 2 gallons per head per day is available. To calculate the amount of rain thus collected, the rainfall in inches and the area of the collecting surface must both be known. The former is ascertained from a rain gauge (p. 138); the latter is measured, and in doing so the slant of the roof is to be entirely disregarded, and the calculation made as if the roof were flat, stretching from wall to wall.

Multiply the number of inches of annual rainfall by the number of square inches of this surface, and thus obtain the cubic inches of water collected per annum. This multiplied by ·0036 converts the answer into gallons. The rainfall is always stated in inches, so if the other data are in feet instead of inches it is necessary to remember that 1 sq. ft. is equal to 144 sq. in., and 1 cubic ft. to 1728 cubic in., and 1 gallon to 6·25 cubic ft. In planning a collecting surface, the area required is determined by the smallest amount of rainfall and the longest period of drought usually experienced in the district.

2. *Means of transit.*—This heading refers to the ways in which the water is led from the collecting surface to the place of storage. Iron or tiled pipes and channels lined with stones are commonly employed. Rain-water separators are useful mechanical contrivances, whereby the first rainfall, polluted with the washings of the collecting surface, is diverted into a watercourse or waste-pipe, and the later clean rainfall is directed to the storage tank.

3. *Storage.*—The simplest contrivance is the common rain barrel, which is to be condemned, especially in malarious districts. If a rain barrel is employed, it must be covered, ventilated, be periodically cleaned, and have an overflow pipe. Tanks of lead, zinc, badly galvanised iron, and wood are bad. They should be built of slates, tiles, stones, concrete, cement, brick, or good galvanised iron, but whatever is used mortar is to be avoided, as it renders the water hard by yielding lime to it. Portland cement should form the binding substance, and all tanks should be provided with storm overflows. The amount of water for which storage provision must be made is calculated by multiplying the number of days which the storage must last by the number of cubic feet of water required daily. The product is the necessary capacity of the tank or barrel in cubic feet. To ascertain the number of days for which storage must be provided, Hawksley's formula is used. This states that the number of days is equal to 1000 divided by the square root of the average annual rainfall in inches. $D = \frac{1000}{\sqrt{R}}$.

4. *Filtration.*—Rain water, since it acquires impurities from the atmosphere and collecting surface, ought to be filtered before being drunk or used for washing food. On the small scale which we are at present considering, this can be done by domestic filters, or the whole supply may be passed through layers of sand and gravel.

5. *Distribution.*—The supply may enter the house by pipes, or be carried in pails, etc., from the storage tanks or barrel. The distribution by pipe does not differ from that in vogue in the case of a public water supply, which is considered in due course.

(*b*) *Wells.*—The well, if it is to be recommended as a source of supply, must pass through an impervious stratum, to obviate the risk of its tapping water contaminated by sewage and organic matter. As far down as the impermeable stratum, the walls of the well have to be carefully built or, as it is called, steined. Bricks put together with cement form a good lining, but are being replaced by rock concrete tubes. The walls, which ought to be surrounded with puddled clay, should project above the ground level, which should be covered with concrete adjacent to the well. The upper part of the walls should slope outwards, and the top should be covered. The area drained by a well has usually a radius about four times the depth of the well. The yield of a well is ascertained by pumping out the water, measuring it, and noting how long the well takes to fill to the original level. The depth of a well to water level can be roughly determined by dropping a stone into it and noting the time it takes to reach the surface of the water. Then the depth $S = \frac{1}{2} gt^2$, g being 32·2 ft. per sec. per sec., and t the time. The well should be sufficiently near the house, and yet isolated from any chance of contamination.

Means of transit.—It is important that the utensils used for drawing the water and conveying it to the house should be composed of sanitary material and kept thoroughly clean. Either a suction or force pump is much to be preferred to the ordinary bucket and windlass.

(*c*) *Springs.*—These are natural outcrops of surface or ground water, and in order that the water from them may be utilised as a house supply, a permanent concrete basin should be formed. Surface springs are intermittent and apt to be impure. Deep spring water is permanent, pure, and palatable.

Means of transit.—Pipes, channels, or personal conveyance.

(*d*) *Rivers and Streams.*—The water is best taken from the centre of the stream or river.

Means of transit.—Personal conveyance. Through pipes, or along channels, by gravitation or pumping. When gravitation is employed, pipes or channels must be screened at the stream or river end.

Method of distribution.—In the case of a large house situated high above the river or stream, a water tower, which is essentially a reservoir at a higher level than the house, may have to be erected to avoid constant pumping.

(*e*) *Lakes and Ponds.*—Much the same conditions apply as to rivers and streams.

B. If the house gets its supply from a public source, it must be fitted for its reception and distribution, and its arrangement in this respect is in every way the same if water from any of the aforementioned private sources is delivered per pipe.

Pipes.—House pipes are made of lead, lead lined by block tin, tar or bitumen; galvanised iron, iron treated by the Barff or Angus Smith's process, and glass- or tin-lined iron. These varieties find their use in obviating the risk of lead poisoning. As a general rule, the main water pipe of the house enters it by the basement, and is carried directly to the large distributing cistern situated near the top of the house. This cistern is not essential if the supply be constant, but it is a sine quâ non in the case of intermittent supplies. The pipe may be of lead or iron, and the former, though dangerous in the case of certain waters, has the structural advantage of being easily bent. The pipe, which is about 2 in. in internal diameter, should be provided with a strong, key-turned stop-cock where it enters the house, to enable the water to be shut off. If the supply be constant, and there be no large cistern, this main pipe gives off branches ending in taps, and no reservoirs are required, save one for the kitchen boiler and one for each water-closet. These branch pipes are usually of lead, and vary in size according to the number of taps each has to serve. The junctions are protected by strong leaden collars fixed by solder, a mixture of tin and lead. Both afferent and efferent pipes should run in special wooden casings, so constructed that they can easily be laid bare and inspected in any part of their course.

Cisterns.—The large cistern already referred to is a tank made of galvanised iron or slate, with cemented joints. A lead cistern is not admissible, and no cistern should have a leaden roof. The cistern should be easily accessible, easily inspected, and readily cleansed. It should be covered, ventilated, and provided with an overflow pipe, which should pass directly into the outside air and discharge over an open gully. On no account must it be connected with any of the drainage pipes or water-closets. Water enters near the top of the cistern, and its entrance is controlled by a ball-valve, which is a hollow metal sphere, so arranged that it floats on the water and rises and falls with it. As the water descends the valve is opened and more water enters, and as the water in the cistern ascends the reverse action takes place. As long as this mechanism acts properly, the overflow pipe is, of course, superfluous. The cistern must hold about three days' supply, and serves the small cisterns and the various house taps. It acts by gravitation, and the pipes leading from it are always full. The small reservoir for the kitchen boiler is frequently made of copper, and is the source of the hot water supply distributed through the house. The water-closet cisterns, or water waste-preventers as they are called, should each hold 3 gallons, and empty completely at every flush. They may be made of slate or wood lined with lead, or more commonly they consist of galvanised wrought-iron, riveted at the angles. Each should have a ball-valve, and be provided with an exit plug, handle, and chain. Some are made to empty by siphon action. One of these small cisterns should always intervene between the water-closet and the supply pipe from the large cistern.

Taps.—Stronger taps are required for a constant than for an intermittent supply, and the pipes should be tapped on each storey of the house.

A *hot water supply* should also run all through the house, distributed either directly from the kitchen boiler or through the medium of a tank. The latter is the better method, and all pipes conveying hot water should be coated with felt. If a tank be present, it is connected with the boiler by two pipes, one carrying hotter water from the upper part of the boiler to the tank, the other returning water from the lower part of the tank to the boiler. A safety valve is required in this system.

Fixed baths and basins.—Both hot and cold water should be laid on to each fixed bath and basin in the house, and these should be in special apartments, and not built in and covered up by woodwork. A bath may be made of porcelain, copper, iron, zinc, or block tin; a basin, of iron or porcelain stoneware: sinks, of glazed stoneware or iron. The ordinary bath supplied is rarely large enough. A bath when half-filled should contain sufficient water and be long enough to admit of an adult man being completely covered from his neck to his toes. The required capacity is from 30 to 50 gallons.

House Filters.—It frequently happens that water requires domestic filtration. The water may be filtered in the cistern, as it leaves the tap, or may be transferred to a separate filtering vessel.

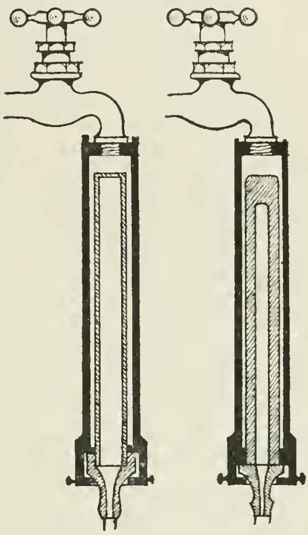
Requisites of a good filter.—(1) It should be of sufficient size; (2) it should yield nothing to the water; (3) the filtering material should yield nothing to the water; (4) it should be readily accessible and easily cleaned; (5) the filtering medium should be removable from the filter; (6) the discharge should be sufficiently rapid; (7) the filtration should be effectual; (8) it should not easily get out of order or be easily broken.

The object of the filtration is to remove micro-organisms, sediment, suspended matter, and colouring agents from the water.

No really good *cistern filter* yet exists. In Professor Rolleston's, charcoal is used as the medium, and the cistern is divided into two by a three-quarter partition. The water enters at the bottom of one compartment, rises through charcoal, passes over the top of the partition, descends through charcoal, and makes its exit by the bottom of the other compartment. The method is good, but the medium is bad.

No *tap filter* absolutely fulfils all the above conditions. The best are the Nordtmeyer-Berkefeld and the Pasteur-Chamberland (Fig. 116). The filtering candle in the former consists of prepared infusorial earth, in the latter of kaolin. Both these filters have the common disadvantage that the discharge from them is not sufficiently rapid. Further, the Berkefeld candle is friable, and after repeated cleanings is apt to become too thin to be efficient. The candles are cleaned by removing from the filters, brushing under a stream of hot water, steaming, or by heating over a spirit-lamp or Bunsen burner. The candle of the Pasteur-Chamberland filter may be cleaned by soaking it for twenty-four hours in 5 per cent. hydrochloric acid, or filtering a hot 5 per cent. solution of caustic potash through it. It is then thoroughly washed with pure water, and boiled in water containing a little sodium carbonate.

The filtration is more effectual in the Pasteur-Chamberland, but more rapid in the Nordtmeyer-Berkefeld. The necessity for cleansing is indicated by a slowing in the yield. They only act well under pressure, hence the necessity of attaching them to the taps. A porcelain filter similar to the Pasteur-Chamberland is the Porcelain d'Amiante, which deserves to be more widely known. All such filters act mechanically, but, in addition, a gelatinous layer forms on the outside of the candles and assists in preventing the passage of micro-organisms. The Berkefeld filter requires cleansing every fourth day.



Pasteur-Chamberland filter. Berkefeld filter.

FIG. 116.

Separate filtering vessels may be composed of various materials, while the contained filtering media also vary. Thus the filter wall may consist of stoneware, glass, or iron, while the medium may be vegetable or animal charcoal, silicated carbon, sponge, flannel, spongy iron, magnetic carbide of iron, "carferal," or asbestos.

The composition of the filter walls is of little importance as long as they yield nothing to the water. Glass on the whole is preferable, as every part of the filter can be seen. Vegetable charcoal is not a good filtering medium. Animal charcoal is in some senses an efficient medium, but it must be specially prepared and well burned. It yields nitrogen and phosphates to the water, which afford pabulum to micro-organisms, and unless it is of proper quality and frequently purified it becomes very foul. It, however, combines mere mechanical filtration with oxidation of the organic matter in the water, but does not wholly arrest micro-organisms. It frees water from lead.

As it cannot be recommended from a bacteriological point of view, its use should be discontinued, especially in the case of drinking-water; but as it is still largely employed, the method of cleaning it must be known. It is used in the form of blocks and as a powder. The carbon block is cleaned by removing it from the filter, washing and brushing, passing through it, first an acid solution of permanganate of potash, and then weak hydrochloric acid. Finally, it is washed by passing several gallons of pure water through it. Purification by fire may also be employed, and is useful for the powder form.

Silicated carbon may also be used in the form of block or powder, and both may be combined (Fig. 117). Sponge and flannel, being organic materials, should never be employed. Spongy iron, as used in Bischof's filter (Fig. 118), is excellent, but the arrangement is complicated, owing to the fact that a little iron passes into the water and has to be removed by subsequent passage through sand and oxide of manganese. Apart from adding iron, this filter removes organic matter, lessens hardness, and may reduce nitrates to ammonia. Magnetic carbide of iron is a carbide of iron pulverised and mixed with sand. The carbide is obtained by roasting red hæmatite and sawdust together in a retort. It has not the disadvantages of charcoal, but is not so good as spongy iron. "Carferal" consists of iron, charcoal, and clay, and is said to answer well. Other mixtures containing charcoal are manganous carbon (charcoal and black oxide

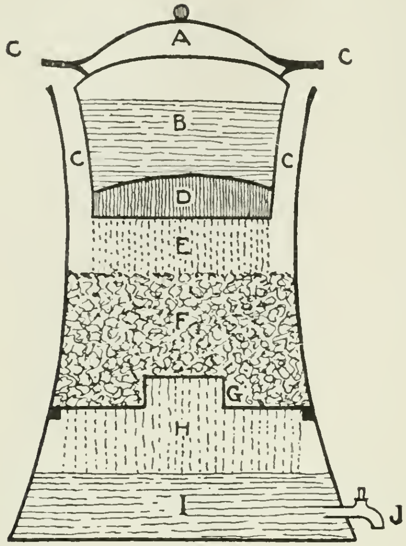


Fig. 117.—Self-aerating filter. *a*, Cover. *b*, Unfiltered water. *c*, Aperture for air. *d*, Filtrant block. *e*, Water being aerated. *f*, Loose filtrant. *g*, Raised part of diaphragm to assist flow. *h*, Water shower. *i*, Filtered water. *j*, Tap.

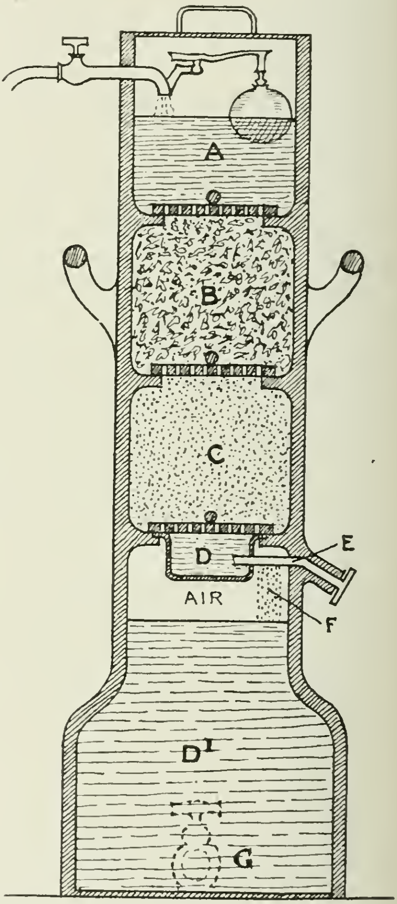


Fig. 118.—Spongy iron filter. *a*, Unfiltered water. *b*, Spongy iron. *c*, Sand. *d*, Filtered water ready for aeration. *e*, Regulator. *f*, Water shower. *d*[1], Aerated filtered water. *g*, Tap.

of manganese), carbalite, used in Crease's ship filter, and Maignen's *filtre rapide* (charcoal, lime, and asbestos). Asbestos forms a good medium, and can be readily purified by means of fire. With regard to all filters, it may be said, that while frequently of value they tend to engender a false feeling of security as regards micro-organisms, and one should aim at securing a pure water supply rather than a good filter. Boiling is the surest way of rendering a drinking-water safe, but it makes it less palatable by driving off the contained gases. At the same time it lessens temporary hardness. The addition of lime or washing soda also lessens hardness, while effluvia and much of the dissolved and suspended organic matter can be removed by the addition of potassium permanganate, which, however, colours the water and necessitates further treatment by alum or filtration. Alum alone tends to clear a muddy water.

OF COMMUNITIES.

Source.—The works required for the water supply of a community depend on the source from which it is derived.

Rain.—This may be collected, as in certain parts of the Continent and India, on large exposed areas composed of concrete, stone, or slate, channelled and connected with storage tanks. This is rendered necessary by the absence of streams or lakes, and is adapted to places where the rainfall is frequently deficient and occasionally excessive. Catchment areas are simply natural collecting surfaces for the rain, which is either gathered from the surface or after percolation through the soil. They should be in high, hilly ground.

Wells.—A sufficient area is required from which water can be obtained, and powerful pumping apparatus, mechanically worked, is necessary to force the water to a spot whence it can be distributed by gravitation. A well should not be sunk so that its area encroaches on that of another well. A rough estimate of the ground drained by a well is obtained by setting off on paper a line representing a drainage area with a diameter of from 5 to 7 miles. Bisect this line and draw a perpendicular from its centre to the same scale equal to the depth of the well. Draw connecting lines, and the result is a cone. The area drained by a well is then more or less of the shape of an inverted cone, and depends on the depression of the level of the well water produced by pumping, and on the nature of the soil. The radius of the base of the cone may be expressed in terms of the depression, and varies from 15 to 160 times the depression. The precautions already mentioned as being essential in the case of a well serving a single house apply even more forcibly to wells forming the water supply of communities. Deep wells, such as artesian wells, will alone yield a sufficient supply for large towns. A village may be served by surface wells, provided they be in a place secure against contamination. Norton's Abyssinian tube-wells are useful in gravelly soil. They consist of lengths of iron pipes driven down, one after another, into the ground, and fastened to each other by screw joints. The lowest section is pointed and perforated, and a pump being fixed to the upper end of the whole tube, a mixture of soil and water is first removed, and then the pure water, accumulating in the cavity formed round the perforated end of the tube, can be obtained.

Springs.—If at a lower level than the place to be supplied, the spring water should be looked on with suspicion, and must be pumped up to a distributing reservoir. If at a higher level, water reaches the reservoir by gravitation. Pumping is also necessary where the spring does not reach the surface. Surface or land springs are never used for a town supply. A number of deep springs set along a hillside, or on a plain surrounded by high hills, may be combined so as to form at least a partial town supply.

Rivers and Streams.—In this case the supply is taken from above the town or village and pumped or run to the point of distribution. In the case of large rivers, where the water is taken direct from the river, the first thing to do is to estimate the quantity of water which can be obtained. The total discharge of the river at any given point is equal to the area of the cross-section of the river at that point multiplied by the velocity at that point. $D = A \times V$.

A certain length of the river is taken, which includes the point at which the discharge is to be estimated. The declivity of the river—in other words, the fall from one end of the measured length to its other end—is ascertained by a levelling staff. The breadth and depth of the river at various parts of the measured length have then to be found. From these data the area of a number of cross-sections can be obtained, and hence the river area at the point of discharge can be estimated. Thus A is determined. To find V, the declivity, the hydraulic mean depth, and a coefficient of friction must be known. The declivity is found by a levelling staff as before. The hydraulic mean depth is the sectional area of the river divided by the wetted perimeter, *i.e.* the bottom of the stream and the parts of the banks which are in contact with the water at the point where the discharge is being considered. The coefficient of friction depends on a variety of circumstances, amongst them being the shape of the channel and the character of the surface. A general value is ·007565. Then V is obtained from the equation $V = \sqrt{\frac{2ghm}{lf}}$, g being the acceleration due to gravity, h the vertical height by which the upper end of the measured length exceeds the lower end, m the hydraulic mean depth, l the measured length, and f the coefficient of friction. Then, as A and V are known, D, the discharge, is $A \times V$.

Another method, in which a mechanical apparatus is used, is that of the rheometer. It resembles the anemometer used in determining the velocity of air currents in ventilation (p. 130). The hydrometric pendulum may be used, the deflection being noted. Pitot's tubes (Fig. 119) ascertain the velocity of the river. They are tubes with one end bent at right angles to the rest, both ends being open. If the aperture in the bent end faces the current, the water will rise in the tube above the level of the river to a height corresponding to the velocity. If it is turned away from the current, there will be a similar fall in the tube; while if it be side-on to the current, the level of the water in the tube will correspond to the river level. The tubes are graduated, so that when the height is observed the velocity is known.

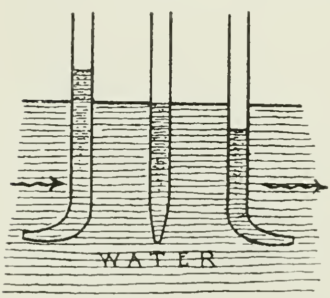


Fig. 119.—Pitot's tubes.

Having calculated the discharge, the works required to utilise it are a weir, settling ponds, and sufficient pumping power.

Weir.—*Site.*—Preferably select a straight part of the river, to prevent injury from strong currents and the risk of flooding the banks on the upside of the weir.

Shape.—It should not be quite straight from bank to bank. It may be curved or run diagonally, or be wedge-shaped, with the apex of the wedge pointing up stream. It is better to raise the weir ends where they meet the banks. All this is for the purpose of preserving the banks from damage and avoiding flooding. From top to bottom the upside of the weir should be vertical and steeply sloped, while the downside should slope gently and be provided with steps forming a tumbling bay (Fig. 120). The bed of the stream may be protected by slightly turning up the end of the long slope. The top of the weir should be 2 or 3 ft. broad, and the banks may be further protected by masonry. Stone and timber combined are used in construction. The object of the weir is to maintain a stretch of water at a constant level, whence it may run into settling tanks.

Settling Ponds.—Even where filtering beds are provided (and these are

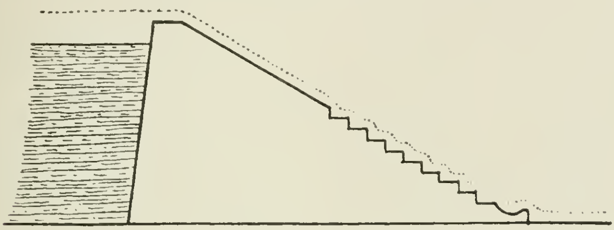


Fig. 120.—Weir. Tumbling bay with heel.

considered later), settling ponds are required to permit gross sediment to subside.

Pumping apparatus.—The water may be pumped from settling tanks directly into the mains, or better into filter beds or service reservoirs for distribution by gravitation. Duplicate plant is required in all cases, and the engine-power necessary is ascertained from the weight of water to be delivered and the height to which it has to be raised. An engine of one horse-power does 33,000 foot-pounds of work per minute, so that the effective horse-power required is equal to

$$\frac{\text{The weight in lbs. of water to be delivered per minute} \times \text{the height in feet}}{33{,}000}.$$

This effective horse-power is the power given off by the engine after it has overcome its own frictional resistance, so that to obtain an effective horse-power of 1 there is required an engine with an indicated horse-power of 1·25. Either a bucket or a plunger pump may be driven by the engine. The former is preferable, as work is done both during the upstroke and the downstroke of the piston. If the water is to be forced into the mains, no service reservoir intervening, air vessels, stand pipes, or loaded valves must be employed, to prevent damage to the mains themselves. Air vessels (Fig. 121) and loaded valves are of the nature of air cushions to prevent thumping and fracturing of the mains from the pump action. They should be placed at the highest point reached by the mains. Stand-pipes (Fig. 122) are different devices, being open to the air, and so designed as to secure a constant pressure in the mains.

Streams.—The question of supply from streams and small water-courses is so intimately connected with that of reservoir formation, that it will be better to defer its discussion.

Lakes and Ponds.—These form natural reservoirs, and lead us to the consideration of collection, purification, storage, and distribution on a large scale. When a lake forms a reservoir, its capacity is determined from a discovery of its length, breadth, and depth, and an estimate is formed of how much its level can be raised without injury to the surrounding country, and its storage capacity thus increased.

The engineering works necessary are very similar to those required when an artificial reservoir is formed (see p. 343).

Artificial Reservoirs.—There are four kinds of artificial reservoirs—(*a*) collecting, (*b*) compensatory, (*c*) storage, (*d*) service.

At this stage we are concerned only with the first two varieties, and these differ solely in the destination of the water which they contain. That in the collecting reservoir is intended for the main community; that in the compensatory, as the name implies, is meant to provide for the wants of small villages, farms, mills, and isolated houses deprived of their ordinary supply by the action of the community in tapping their water sources. A collecting or compensatory reservoir may gather water from a large number of rivulets and rills in a catchment area, or from the impounding of a fair-sized stream. Rain falling on a catchment area partly evaporates, partly percolates, partly "inclinates," *i.e.* trickles over the surface and joins the small water-courses. The amount available for water supply depends on—(1) the quantity and rapidity of the rainfall; (2) the water-bearing capacity (geological formation) of the soil; (3) the geographical position and physiographical characters of the area; (4) the nature and quantity of the vegetation; (5) the temperature and moisture of the air; (6) artificial drainage.

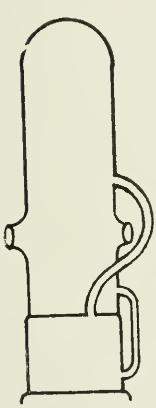


Fig. 121.—Air vessel.

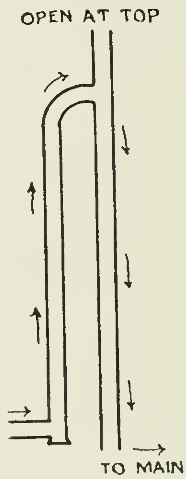


Fig. 122.—Stand-pipe.

In the British Islands the available rainfall averages 30 gallons per day per acre per inch of annual rainfall. The ratio of the available to the total rainfall varies with the geological features of the district. The rainfall itself is estimated by means of a rain-gauge (p. 138). In considering a town supply from a catchment area, the population must be known, the extent of the area, the rainfall, the available rainfall, the uses for which the water is required, and the quantities necessary for each purpose. If a stream is to be impounded, or the water of a large number of rivulets to be collected, the yield may be determined by various methods, and it is advisable to test the water current at different times, and so to obtain an average.

1. *Weir gauging.*—This is the most accurate method, and for it is required a fairly straight portion of stream near the site of the reservoir, a notched obstruction in the stream with the exact area of the notch known, and a graduated staff to estimate the depth of the stream. A weir is placed across the stream. It may be made of concrete or planks, and must reach from the surface to the bottom of the stream and completely dam back the current. A still-pond is thus formed behind the weir, and in it the measured staff is erected and a reading of the depth taken. The notch or gap in the weir may be rectangular or triangular if reaching to the surface of the water. If entirely beneath the surface, it takes the form of a square or circular aperture. Determine the difference in level between the staff measurement and the centre of the bottom of the notch. This gives the "head" of water. If the aperture be entirely below water, the "head" then is the difference in level of the water on each side of the weir. The "head," the size of the gap, and a certain coefficient of friction, varying with the shape and size of the gap, all being known, the discharge of the stream is obtained from an equation—

D, the flow in cubic ft. per second, is equal to $\frac{2}{3}$ C $\sqrt{2g\text{H}} \times \overline{bh}$, where $\frac{2}{3}$ C = the coefficient of efflux ; $g = 32 \cdot 2$ ft. per sec. per sec. ; H = the head of water ; $b =$ the breadth of the gap, and $h =$ the height of the gap, $b \times h$ being its area.

An alternative formula is—

$$\text{D} = 5 \cdot 35 \ \text{C}b\sqrt{h^3}.$$

These formulæ hold good if the gap reaches to the bottom of the stream. When in a small stream a thin notched plank is used, the notch is usually made exactly 1 ft. in width, and the discharge of cubic feet of water per minute is known from a table, when the depth of water in inches flowing over the notch is read off. If the velocity be great, it may be necessary to convert this velocity into "head," which is done by partly shutting off the rush above the weir by means of a so-called shutter let down into the water, but not reaching to the bottom. The calculation is then the same as before.

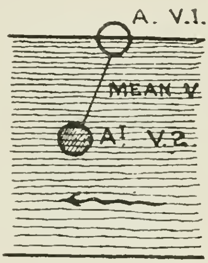


Fig. 123.—Floating spheres.

2. *By floating bodies.*—(*a*) Choose a smooth, uniform portion of the stream of fair length, and ascertain its breadth and average depth. Float a cork from one point to another along the measured length, and note the time taken to traverse the distance. Thus the surface velocity is known. The mean velocity is four-fifths the surface velocity. The mean velocity multiplied by the sectional area = Discharge. The mean velocity may be got from the surface velocity by De Promy's formula, $v = \text{V} \times \dfrac{\text{V} + 7 \cdot 776}{\text{V} + 10 \cdot 335}$. V = the average surface velocity.

(*b*) With a hollow sphere (A) (Fig. 123) determine the surface velocity. Couple this sphere by a thin wire to a weighted sphere (A^1) which floats beneath the surface, half-way to the bottom. Let the whole drift down a measured distance of the stream, and note the time taken. Then the mean velocity of the spheres, v, is equal to $\dfrac{v^1 + v^2}{2}$, $v^1 + v^2$ being the velocities of the upper and lower spheres respectively. V, the mean velocity of the stream = $2\ v - v^1$.

The Reservoir Basin.—This, as a rule, is a natural valley whose outlet is dammed up, and in which the water of the catchment area or the stream accumulates. In selecting a site, the following particulars require attention, in addition to the available rainfall already considered :—

1. The area of the watershed. Ordnance maps are of value. They give the contour lines and the ridge or watershed lines. On them are also placed the "bench marks," figures which indicate in feet the height of various spots above ordnance datum, usually sea-level. The ordnance survey inscribe broad arrows, or the letters B.M., on buildings, milestones, or rocks at points the heights of which they have determined.

2. The geological formation of the bed of the valley, especially as regards the impermeability of the underlying strata and their liability to be affected by earth movements. This is determined by sinking test pits.

3. The character of the neighbouring soil. It must not contain deleterious substances, such as much manure or poisonous metals, which may be washed down or dissolved by rain or stream water.

4. The easy access or otherwise to suitable building material, especially good puddle clay required for the construction of the dam.

5. The height of the proposed valley above the place to be supplied. Nowadays the distance of the reservoir from the town is entirely a question of pounds, shillings, and pence. Further, the valley must be low enough to collect all the water on the gathering ground.

6. The size of the valley itself, which must hold a supply sufficient to maintain the normal distribution even during three consecutive dry years, which Hawksley and Symons have proved to have a mean rainfall of four-fifths the average rainfall of a series of dry and wet years combined. In the wettest year the rainfall will be one-half more, in the driest one-third less, than the average rainfall. The acreage of the necessary reservoir basin can thus be determined from the formula : $G = 62{\cdot}15\ A\ (\frac{4}{5}\ R - E)$; where G = daily quantity in gallons required to be withdrawn from the reservoir, A = acreage, R = average rainfall of a series of years, E = the quantity lost from the reservoir by evaporation. The evaporation is ascertained by exposing boxes of definite area filled with water, and noting the diminution in quantity, allowance being made for any concurrent rainfall.

In warm, dry climates, in computing the amount of water derivable from a watershed, it is advisable to omit the area of the reservoir from the gathering ground considered, *i.e.* the evaporation from the water surface of the reservoir is regarded as being equal to the whole amount of rain which falls on the surface of the water in the reservoir. In temperate climates, evaporation rarely exceeds 60 per cent. of the rainfall on the surface of the reservoir. In very wet countries a smaller reservoir will suffice than in dry ones, since it is replenished at more frequent intervals, and the amount of water in the basin can always be regulated. In wet districts 150 days' supply should be stored, in dry areas 200 is necessary. Further, it is customary to consider one-third of the total quantity of water impounded an ample allowance for compensation purposes.

7. The shape of the valley, which should be deep and narrow to obviate the necessity of erecting a long embankment and to lessen evaporation.

8. The contouring of the valley to enable one, knowing the water depth at every point, to at once calculate the number of gallons in store.

Site of Dam.—It is important to determine the soundness of the strata on which the dam is to rest, and the nature of the valley sides with which its ends are to be incorporated.

Preparation of Basin.—Unless the reservoir is on a huge scale, it is customary to free the basin from vegetation and to line its sides above the usual water level with blocks of masonry. Any outcrops of permeable rock in its bed should be covered over with a thick layer of puddle clay. The bottom may be strewn with clean gravel and large stones.

Construction of Dam (Fig. 124).—The materials used may be earth, clay, or masonry. The choice depends on the propinquity of the various materials to the site of the dam, on the shape of the valley outlet where the dam is to be built, and on the water pressure to be withstood. Other things being equal, a dam of masonry is the strongest, and is required when the outlet is narrow and deep, or where a very large reservoir is to be made. An earth dam will suffice where the embankment is long and shallow. In any case a dam must be stable as a whole and in every layer; in other words, it must withstand its own weight, water pressure, and the friction action between its component parts. A masonry dam should have a good foundation, does not require to be so

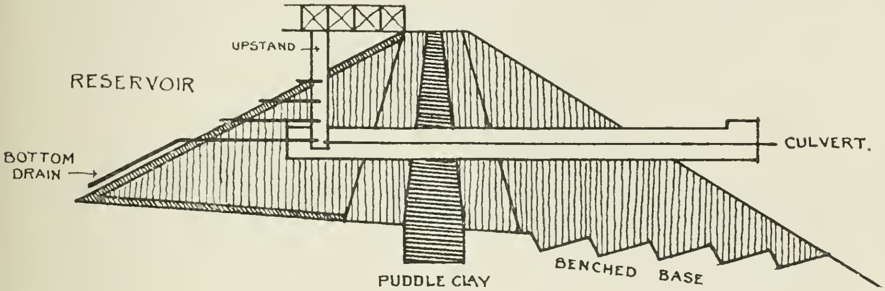


Fig. 124.—Reservoir dam.

thick as an earthen embankment, has an external vertical side, and an internal face nearly vertical. The stone employed must have little water absorbing power, and must be put together with hydraulic cement. In building an earthen dam, a trench is first sunk down to the underlying impermeable rock or clay. This trench is filled in with puddle clay, which is well punned down, and which is continued upwards in the earthen dam, forming a central layer throughout its whole length. The dam itself is built up from the level of the top of the trench, the earth and puddle clay rising together. Each layer is laid concave upwards to increase the coherence of the dam and to force out moisture. The surface on the water side may be lined with asphalt or concrete, and faced with large stones. Above the water level it is coated with sods, which also line the top and the external slope. Nothing but herbage should be permitted to grow on the earthen mound, as tree roots would tend to endanger its stability, and the trees themselves act as levers in a heavy wind. The dam should rise at least 3 ft. above the highest water level, and both sides should slope away from each other, the external slope being the steeper. The thickness at the top should be one-third the height. In order that the resultant pressure may always act at right angles to the base, the outer half of the base should be benched, *i.e.* cut into the form of steps (Fig. 124).

Pressure on Dam.—The dam is exposed to the pressure exerted by the water in the reservoir and the effect of gravity. The former acts on the surface in contact with the water at the junction of its upper two-thirds with its lower one-third, and is at right angles to the slope. The latter acts vertically through the base of the dam from the centre of gravity. The resultant pressure of these two forces cuts the bed of the dam, and must do so within its middle third if the dam is to possess stability of position. The pressure exerted by the water can be calculated if the depth of the water and the extent of the wetted surface of the dam be known (Fig. 125). The pressure on each foot length of wall is the weight of as many cubic feet of water as there are square feet in a right-angled triangle (CBD) constructed on the water-wetted face as a base, and having a perpendicular (BD) equal to the vertical depth of the water (AB). In order to lessen the cost, some dams are now being constructed without a puddle clay trench and core, the layers of earth being impacted together by steam rollers.

Accessories.—*Waste weirs* are required to prevent the water rising too high in the reservoir. They are placed in the most convenient position for overflow into a water-course, and the water passing over them falls over a tumbling bay or bye-wash, and finds its way to the stream.

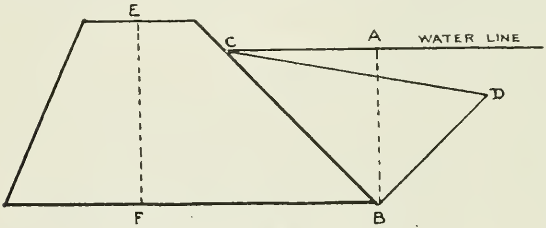


Fig. 125.—Pressure on dam.

Self-acting sluices.—These are supplementary to the waste weirs, and necessary in time of floods.

Vertical tubes set in the reservoir to carry off excess. These communicate with channels passing to the water-course.

Separating weirs are placed at the entries to the reservoir, and designed to keep back dirty and mud-laden water in time of floods.

Straining wells screened by wire gauze are used to exclude the grosser impurities before the water passes to the filter beds. The water supply leaves the reservoir by means of a pipe situated in a culvert or tunnel with an internal blind end, constructed through the dam, and lined with puddled brick. It communicates with the water in the reservoir by means of a vertical tube called the upstand, into which pipes open leading from the basin at different levels. The upstand may be built out in the reservoir, or in the dam itself, as shown in Fig. 124. The lowest pipe connected with the upstand is bent downwards so as to reach and drain the lower levels in the basin.

Purification.—This may, on a small scale, be carried on in the reservoir itself, by permitting the presence of fish and harmless forms of low animal and vegetable life. These act by causing oxidation of the organic matter.

On a large scale, purification is employed with many objects in view. Sediment and suspended matters may have to be removed, and to a certain extent the micro-organisms which may be present. Injurious or unsightly colouring matter may have to be got rid of, while it may be necessary to free the water from excessive hardness or injurious metals, such as lead, or prevent it absorbing lead in its passage to the place of consumption.

Ordinary purification is performed by large filters, mainly composed of sand and gravel, and there should be at least a double set.

Construction of Large Filter Beds (Fig. 126).—The walls are of concrete, stone, or brick, and slope outwards from the base. They are usually lined on the inner face by a layer of puddle clay. The bottom is of concrete or puddle clay, and is laid on a double slope, *i.e.* there is a slope from the long sides to the centre of the filter. Tiled drains conduct the filtered water to a culvert which runs along the centre of the bed and slopes towards one end of the filter. It conveys the water to its next destination. It is necessary to provide ventilating pipes to admit of the escape of air forced out by the percolating water, otherwise no flow would take place. These pipes run from the bottom of the filter beneath the tiled drains, and open to the air at the sides of the filter bed. Above the drains, from below upwards, broken stones, gravel, and sand are placed. These are the essential constituents. In addition, there may be layers of coarse sand and broken shells or bricks. The whole thickness is from 5 to 6 ft., the upper 2 or 3 ft. being composed of fine sand.

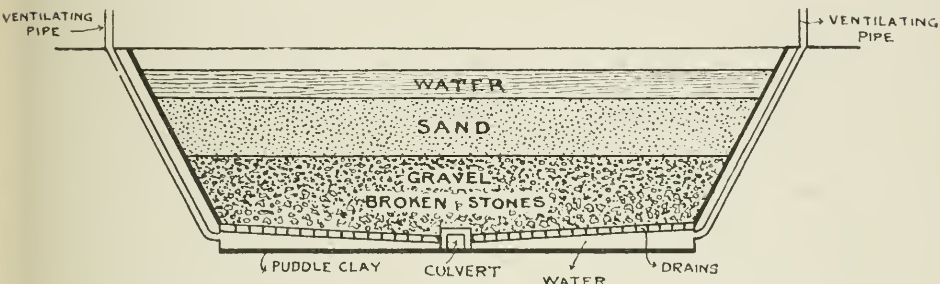


Fig. 126.—Filter bed.

The following table shows the constitution of a filter bed from below upwards:—

Materials.	Inches.
Coarse stones	12
Small stones	4
Coarse gravel	3
Medium gravel	5
Fine gravel	6
Coarse sand	4
Fine sand	32

The water is run on to the top, and the flow is controlled by a regulating valve. The depth to which it is allowed to accumulate above the level of the sand depends on the character of the water. A constant "head" is however maintained, so that the rate of filtration remains the same. As a rule, it should stand 3 ft. deep on a new bed for twenty-four hours before any is allowed to pass through. This permits of the formation of the "vital" layer due to sedimentation. The rate of filtration ought to vary with the purity or otherwise of the water. Three to 6 gallons per hour per square foot of filtering surface is the usual rate. According to Koch, it should be 100 mm. or 3·94 in. per hour; 6 in. per hour is equivalent to the filtration of 3 gallons.

A filter acts both mechanically and by an aerobic bacteriological process, a gelatinous layer forming on the surface of the filter bed after water has been passing through it for some time. This layer contains numerous micro-organisms which are the effective agents, utilising organic matter, and, by the gelatinous slime they form, arresting the passage of other micro-organisms. Thus a filter is not efficient from a bacteriological point of view until it has been in action for some time, and this layer should not be disturbed until it has rendered the filter inoperative. Aeration alone often suffices to keep a filter in good working order, and therefore its use should be intermittent and duplicate plant provided. Thorough cleansing is carried out by removing the fine surface sand and washing it. The effluent should not, according to Koch, contain more than 100 micro-organisms per 1 c.c. For every 10,000 gallons of water to be filtered per day, the rate of filtration being respectively 3 and 6 gallons per hour per square foot, 14,000 to 27,000 square feet of filtering surface are required.

SUMMARY.—Such a filter as has been described removes sediment and suspended matters, arrests the passage of micro-organisms, and exposes any pathogenetic micro-organisms to the action of non-pathogenetic varieties. Further, it removes colouring matter, hardness, and to some extent lead, it oxidises organic matter by aeration, and changes ammonia and nitrites to nitrates.

Magnetic carbide or Bischof's spongy iron may be used on a large scale as filtering media, and are specially useful in the case of river waters polluted by dyes and chemical effluents, but have no other advantages over sand, and are in some respects not so good. These filters act mechanically like sand, but, in addition, they decompose some of the water passing through them, liberating oxygen, which oxidises the organic matter. They have, however, little effect in removing bacteria from the water, though they act powerfully in freeing water from lead. They lessen hardness and reduce nitrates to ammonia. The spongy iron filter has to be kept covered with water, otherwise the medium becomes dry and inoperative. Water which has passed through it cannot be stored for any time, as it deteriorates, and such water contains iron in small quantities, necessitating a second filtration through black oxide of manganese, sand, and gravel.

REMOVAL OF HARDNESS.—As already seen, hardness may be temporary or permanent, the former being due to calcium carbonate, the latter to calcium sulphate, salts of magnesia, chlorides, silica, iron, and alumina. The efforts are directed to the removal of the temporary hardness, a total hardness above 8 degrees being undesirable.

1. *Mere exposure of water to the air combined with stirring.*—Carbonic acid is got rid of, and the insoluble carbonate, which has been partly held in solution by the carbonic acid, is precipitated.

2. *Clark's process.*—This consists of adding hydrated calcium oxide, which has a greater affinity for carbonic acid than has the carbonate. Consequently the carbonate, being no longer held in solution, is thrown down, while at the same time an excess of carbonate is formed which is also precipitated—

$$CaCO_3 + CO_2 + CaH_2O_2 = 2CaCO_3 + H_2O.$$

Thorough mixing is essential by means of rakes or fans, and settling tanks are required, the subsidence taking from ten to twelve hours. The quantity added is 1 oz. per 100 gallons for every degree of temporary hardness, *i.e.* for each grain per gallon. Not only is hardness got rid of, but suspended matters are carried down by the bulky precipitate.

3. *Porter-Clark's process.*—This is a modification of the last, in which the precipitate, instead of being allowed to subside, is removed by filtration under pressure through canvas or linen cloths.

4. *Alum process.*—Alum in a strength of 6 grs. per gallon softens hard water by combining with the calcium carbonate to form an insoluble calcium sulphate and aluminic hydrate. The bulky precipitate carries down with it the suspended matters.

5. *Howatson's process* is an attempt at removing some of the permanent hardness, as well as the temporary, by the addition of caustic soda and slaked lime combined with subsidence in settling tanks.

6. *Maignen's process* advocates the addition of a powder known as "anti-calcaire," which is composed of lime, sodic carbonate, and alum. The lime and sodic carbonate are the chief agents, attacking the lime and magnesia, while the alum increases the volume of the precipitate and carries down suspended matters.

Removal of Lead and Prevention of Lead Absorption.—Removal is effected by filtration through sand, spongy iron, or charcoal. Waters, such as acid moorland waters, which tend to dissolve lead, may be prevented from doing so to a dangerous extent by reducing the acidity to a point below ·5 parts per 100,000, or rendering them alkaline. This is effected by the addition of blocks of limestone or magnesian limestone to the water in the reservoirs, or the treatment of the water in tanks by lime along with chalk, 80 to 90 grs. of lime per gallon being added. At Bradford, 3 grs. per gallon carbonate of lime is used as a preventive; at Wakefield, carbonate of soda is employed.

Removal of Suspended and Colouring Matter.—Subsidence in the reservoirs or in settling tanks, filtration, and the addition of any of the chemical precipitants, all tend to remove suspended matters. A soft water containing suspended matter may be cleared by treatment with calcic chloride and sodic carbonate followed by alum to induce precipitation. Colouring matter is best removed by filtration.

Distillation.—This method of purification is chiefly applicable in the case of ships, especially those undertaking long voyages, but it cannot be relied upon if the water is obtained from a very impure source (harbour contents), as such water may contain hurtful volatile substances which may distil over. If the source be moderately pure, it is an absolutely safe mode of purification.

Sterilisation.—*Ready methods.*—The terrible ravages of enteric fever amongst our soldiers in South Africa has brought into prominence the question of some easy, simple, and rapid method of freeing drinking-water from undesirable or pathogenetic microbes. The methods at present in vogue and their value have been thus summarised by Major Macpherson, R.A.M.C. The three methods available are—(1) boiling, (2) chemicals, (3) filtration.

1. Boiling.—*Open fires* possess the advantages of efficiency and simplicity of application.

Disadvantages.—Fuel not always obtainable. Water becomes unpalatable. Too lengthy a process. Necessitates porterage of fuel in many cases, and in a campaign large quantities of water have to be boiled overnight, and carried the next day.

Special apparatus devised to economise fuel, rapidly cool the water, and prevent loss of gaseous constituents. The three kinds are (*a*) Vaillard-Demaroux, (*b*) Maiche, (*c*) Waterhouse-Forbes. The last has the advantage of weighing much less than the others, while having the same output of water.

2. Chemicals.—*Disadvantages.*—Few are effective and useful. They are apt to add taste and colour to the water. *Varieties used.*—(*a*) *Permanganate of potash.*—Unreliable. (*b*) *Hypochlorite of calcium*, ·02 grm. to 1 litre. *Disadvantages.*—Deliquescent and cannot be used as tabloids, so that the amount to be added is not easily graduated. Apt to render water unpalatable if used in greater quantities than above. (*c*) *Schumberg's bromine process* (p. 17).—Hyposulphite and carbonate of sodium may be used instead of the ammonia. *Disadvantages.*—Cumbersome and lengthy for use in the field. (*d*) *Bisulphate of sodium* (Parkes & Rideal), 1 grm. to 1 pint; used in the form of tabloids. *Disadvantages.*—Apt to crumble and deliquesce in carriage. Impart a taste to the water and take at least fifteen minutes to kill the *B. typhosus.* If largely taken, may induce thirst. (*e*) *Ozonisation.*—The treatment of water by forcing through it air ozonised by electricity is effectual in purifying and sterilising drinking-water, provided the latter be not too polluted. Preliminary filtration is advisable. The process is applicable to communal supplies, is not very expensive, and is now in use at Lille and Moscow. The concentration of ozone required and the time occupied in the process vary with the degree of pollution of the water. Ozone is only effectual in the presence of moisture, but the air to be ozonised should be dry and perfectly freed from dust particles and its carbonic acid.

3. Filtration. — The Berkefeld field-service filter is the best. It possesses an air pressure chamber without which filtration would be too slow.

Disadvantages of filtration.—Bougies brittle, get clogged, and are not easily cleaned on active service.

Storage.—This is effected in storage and service reservoirs, the latter being small collections designed to supply certain parts of a town or to provide against emergencies or accidents. They contain a few days' supply, and are near the site of distribution. If below the site of the collecting reservoir, they lessen the pressure in the pipes passing from them. In a hilly town there should be several service reservoirs. If there be only one, it must be on a height overlooking all the other eminences. The pressure on the pipes is unequally distributed if only one reservoir is supplied to such a district. These reservoirs may be made of brick, stone, or, if small, of cast-iron plates. In all cases they should be lined with hydraulic cement and covered over so that the filtered water may be kept cool, at a uniform temperature, fouling by dust, etc., prevented, and the growth of vegetation discouraged. Underground storage tanks present many advantages.

Distribution.—The water has to be distributed from the large collecting reservoir, first to the filter beds and the storage or service reservoirs, and then to the point of consumption. As a rule the water performs the first part of its journey in open aqueducts or channels where it is not under pressure. This is the cheaper method. The channel itself should be of such a shape and size as to give the greatest hydraulic mean depth. This is secured by employing a semicircle, a semihexagon, or a half-square. A very good form is a half-iron cylinder lined with brickwork and hydraulic cement. Nearer the point of consumption pipes take up the function of the open channel, and these pipes require to be laid on a steeper slope than the channel. The slope of the pipes should be greater than that of the conduit. This ensures a greater velocity, and cheaper and smaller pipes can therefore be employed. In the conduit the velocity should not be less than 1 ft. per second, and not more than 4 ft. per second.

Pipes.—The pipes are usually made of cast-iron. Sheet-iron pipes, lined and coated with hydraulic cement, may be used, and for special purposes, such as crossing rivers and valleys, wrought-iron or steel plates may be employed. In the case of cast-iron pipes the metal must be soft and tough, and is a mechanical mixture of iron and carbon. The casting has to be very carefully done in vertical sand moulds, and all pipes must be tested hydraulically. The pipe is fixed, any joints rendered water-tight, and water is run into it under pressure. When twice the working pressure has been obtained, the pipe is tapped all over with a hammer, and any flaws are thus detected.

Each pipe is about 9 ft. in length, and has to be coated internally and externally to preserve it from water action on the metal. Angus Smith's varnish, consisting of pitch free from naphtha, asphalt, oil and tallow, is frequently used. A bath of the mixture is prepared at a temperature of not less than 310° F. The clean pipes, heated to a similar temperature, are slung into the bath, allowed to drip, and then dipped again, the process being repeated three or four times. Care must be taken to see that the inner surface has been properly coated.

In Barff's process the temperature of the pipe is raised to a white heat by superheated steam, and a protective oxide is thus formed. Galvanised and glass-lined iron pipes are also employed. Pipes vary from 2 in. to 4 ft. in diameter, but nothing under 4 in. is suitable for street pipes.

The necessary thickness may be obtained from the equation $t = \frac{p \times d}{2f}$, where t = the thickness in inches, p = the excess of possible internal over external pressure, d = the internal diameter in inches, and f = the factor of safety, *i.e.* the safe limit of stress in the material; f is usually taken as 10, as you assume that the metal is only one-tenth as strong as it should be. A good cast-iron pipe should resist a pressure of 18,500 lb. per square inch. It is much better, however, to determine the elastic limit of the material by a special instrument. As long as its elasticity is unimpaired, the pipe is safe. In calculating the necessary strength, allowance must be made for irregularities in casting, alterations in the sand moulds, and hydraulic shock.

Laying and jointing of pipes.—Pipes must be laid on true beds, and special care must be taken in laying the faucit so as not to leave a space beneath the part of the pipe adjoining it. The faucit end should point uphill so that it supports the spigot, and a special excavation should be made in the earth to receive the faucit. The fall of the bed must also be constantly true. Pipes must be laid in perfectly straight lines, and curved pieces inserted where corners have to be turned. They ought to be buried at a depth of from 4 to 6 ft. to prevent fracture owing to frost or to shock from above.

Hub and spigot joints are commonly used, the interval between the spigot and the faucit being packed with gaskin (tow and hemp), on the top of which molten lead is run. This form of joint is very convenient where there is a bend in the pipe, but was condemned by the Rivers Pollution Commission, impurities being taken up from the gaskin. The following form is recommended, or in the case of the largest mains a pointing of the inner aspect of the hub and spigot joint with Portland cement. In the turned and bored joint the smooth conical spigot fits into a corresponding surface in the faucit, both surfaces having been payed over with a mixture of tallow and whiting, and the joint externally protected by a layer of Portland cement. Wrought-iron pipes may be laid end to end, and the abutting ends surrounded by a sleeve of sheet-iron 8 in. long, the interval being filled in with cement, and the whole joint enclosed in mortar and cement. If steel plates be employed, they must be riveted together. The largest pipes are termed the water mains, then there are submains or water service pipes, and from these the communicating pipes pass to the buildings to be supplied. These latter have to be adapted to the maximum hourly demand and to the necessary head in the streets. These factors vary in the different districts of a town, and render it necessary to have different sized pipes.

Where required, the mains should be fitted with sluices and air vents, while hydrants for use in case of fire must be provided. The speed in the mains should be 2 to 3 ft. per sec., and it is advisable, where traffic is heavy, to place the mains on each side of the street instead of down its centre. There is thus less risk of fracture and less disturbance of traffic when the pipes are undergoing inspection or repair. Further, all water pipes should be laid as far away as possible from sewers and gas mains. In large towns about 1 mile of district mains is needed for every 2000 to 3000 people.

In any water-pipe system "dead ends" or cul-de-sacs are to be avoided, and a circulating system employed, to prevent deposit. If "dead ends" exist, each must be provided with a "blow off" cock or a "scouring valve."

We have thus again reached the house, the water pipes in which have been already considered. It remains to contrast the *constant* with the *intermittent* supply, and note their respective advantages and disadvantages. In the case of the constant supply, the house-taps may deliver water direct from the water service pipes, which are always running full. In the intermittent supply, on the contrary, they are frequently empty, and house cisterns become a necessity.

Advantages of the constant supply.—No storage is necessary, and therefore the cleaning of cisterns is obviated. It is more convenient for consumers. Waste-pipes from sinks, etc., opening in visible situations and not into drains, act as warning pipes if taps are left running and water-waste is proceeding. There is less risk of water pipes drawing in impurities. There is less risk of rust forming in the pipes. The danger of fracture from frequent hydraulic shock is diminished.

Disadvantages.—Possibility of excessive consumption and waste from leakage owing to constant pressure. Stronger fittings are needed. Waste in the low-lying parts of a town may deprive elevated districts.

Advantages of the intermittent supply.—It is less expensive. There is less waste inside houses.

Disadvantages.—Storage is required. In tenements the cisterns are invariably too small. It is less convenient for consumers, and tends to a miserly use of water. There is great danger of the empty pipes sucking in impurities, such as sewer air, gas, and liquid filth, when the water has been shut off, and the taps or faulty joints permitting the escape of the contained water tend to produce a vacuum. The water is often stagnant. The pipes tend to corrode and lead absorption is favoured. It is bad in the case of fire.

Charges for Water.—These are made by rate or by meter in the case of house supplies. The former is the better mode, as the latter tends to induce a false economy. For trade purposes the meter has advantages.

Prevention of Waste.—Waste without the house is common in the case of the constant system owing to broken pipes and faulty joints. It is best detected by Deacon's waste-detecting meter, which indicates the amount of water passing along a pipe, and thus any excessive consumption attracts attention to the fact that waste is going on. A meter being placed at various parts of the system enables a diagnosis to be made as to the probable position of the leak.

The Deacon waste-detecting meter consists of a cast-iron body with two socket ends by which it is connected to the main. In this body is a vertical hollow gun-metal cone, so arranged that all the water enters at the top of the cone and passes to the outlet. The cone contains a horizontal disc attached to a vertical stem, and this disc at the top of its stroke exactly fits the small end of the cone. The vertical stem is connected with a recording apparatus consisting of a revolving cylinder turned by clock-work. The disc is counterbalanced by a weight, so that when no flow is passing it fills the small end of the cone. When water flows through the meter the disc is forced down, leaving a water-way between the disc and the cone, the area of which is proportional to the amount of water passing, and the movement of the disc is graphically recorded on a chart attached to the revolving cylinder. To ascertain the waste in any district, the district is isolated by sluice valves, and the whole supply to the district passes through the meter. A chart is obtained of the water used during twenty-four hours, and from it is known—(*a*) the quantity supplied in gallons per hour; (*b*) the quantity wasted in gallons per hour; (*c*) the rate of flow at any part of the twenty-four hours. The average flows for each hour added together give the total quantity for twenty-four hours. The lowest night flow multiplied by 24 gives the total waste per day, and deducted from the total quantity gives the quantity of water actually used. By shutting off separate valves or stop-cocks in the district, and making similar observations, the waste may be located in streets or houses. The diagnosis is rendered more exact by the application of a stethoscope or steel sounding-bar to the pipe or main. There is no noise in a sound pipe, but escaping water can be heard yards away from its point of exit. The meter does not cause any loss of head or appreciably interfere with flow. Town water mains should be tested hydraulically every six months.

V. THE DISPOSAL OF SEWAGE AND REFUSE, AND THE DRAINAGE OF SITES AND SUBSOILS.

A. HOUSE.

I. *WET METHOD.*

I. **Sewage.**—This is a water-carriage system, and the requisite water supply has already been traced into the water waste-preventers or small cisterns used for flushing the water-closets. Each water-closet is best placed against an outside wall, and must have its own cistern, preferably in the same room with it, and must occupy an apartment provided with adequate cross ventilation, plenty of light, and of sufficient area. A lobby should intervene between the water-closet room and the adjoining part of the house, and this lobby should be cross-ventilated (Fig. 127). A bath and wash-hand basin are the only admissible companions of the water-closet, and then only if proper pipe disconnections are perfectly constructed. Where there are several water-closets, one should be built above the other in a projecting part of the house, so as to ensure adequate ventilation, convenience in drainage, and exclusion of

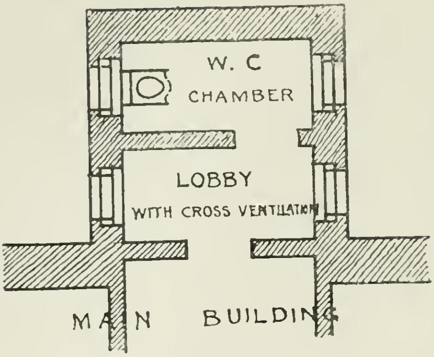


FIG. 127.—Position of water-closet chamber; cross ventilation.

the water-closet system from the rest of the house.

CISTERN (p. 334).—It should hold 3 gallons, being emptied at each flush, and should be situated 8 ft. above the water-closet. It is designed to yield a flush which will scour out the sides of the basin and carry away the contents with a rush. It acts by means of a valve or a syphon (Fig. 128), and should be as noiseless as possible. The pipe connecting it with the closet should have a diameter of $1\frac{1}{4}$ to $1\frac{1}{2}$ in. The main-supply cistern of the house must on no account be in the water-closet apartment.

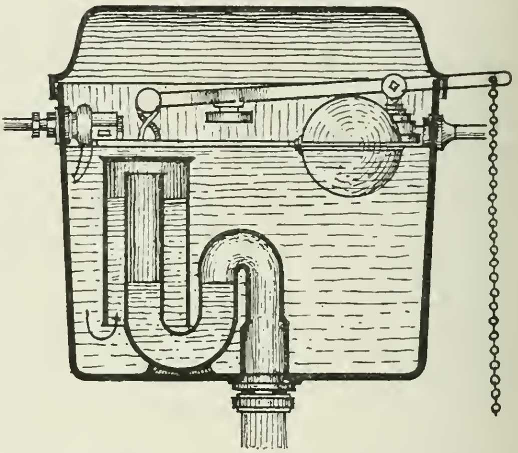


FIG. 128.—Water waste-preventer or water-closet cistern.

WATER - CLOSETS. — A good water-closet apparatus should—

1. Have no wooden casing, so that it is easily accessible in every part, and be provided with a hinged seat, so that the basin can be used as a urinal without offence. Further, there should be a supplementary seat having a smaller aperture suitable to the requirements of children, and in no case should the seat be too far above ground level.

2. Be constructed of materials which will not rust.

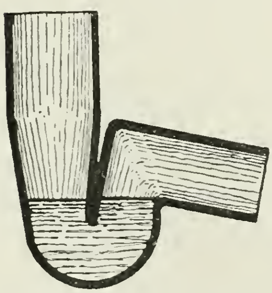


FIG. 129.—Anti-D syphon trap.

3. Possess a basin of such a size and shape as will expose its whole surface to the scouring action of the flush.

4. Be of as simple a mechanism as is possible.

5. Have a rapid and efficient flush.

6. Have a trap immediately under the basin, and above the floor-line. This trap must be of the anti-D (Fig. 129) or syphon (S-shaped) form.

7. Possess joints impermeable to gas and water.

There are four chief types of closet, and of three of these there are endless varieties. The types may be classified as the pan, the valve, the wash-out, and the wash-down closets. It may at once be said that any movable mechanical apparatus for retaining water in the basin, as is present in the old pan and valve closets, is to be condemned.

Pan Closet (Fig. 130).—This is a very objectionable form, condemned by the model by-laws of the Local Government Board, and should be removed wherever found. The objections to it are—

1. It is cased in wood.
2. It is complicated in mechanism, and contains a movable copper pan for retaining water in the basin. This is liable to rust, perforate, fail to fit closely, and get out of order in action.
3. There is an iron container below the basin which holds no water, and becomes extremely foul, so that if the pan above is imperfect, a nuisance is at once forthcoming, and danger may result. There is also emanation of gas from the container every time the closet is used.
4. There is a bad form of water seal, called the D trap, beneath the container, and the waste pipe from the "safe" or leaden floor-tray, which protects the floor from leakage, opens into the water seal. This trap is below floor-level, and retains excreta.

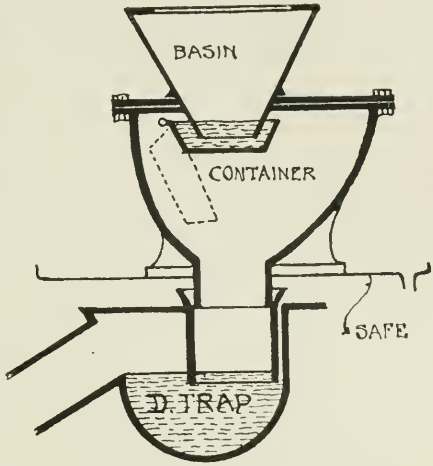


Fig. 130.—Pan closet.

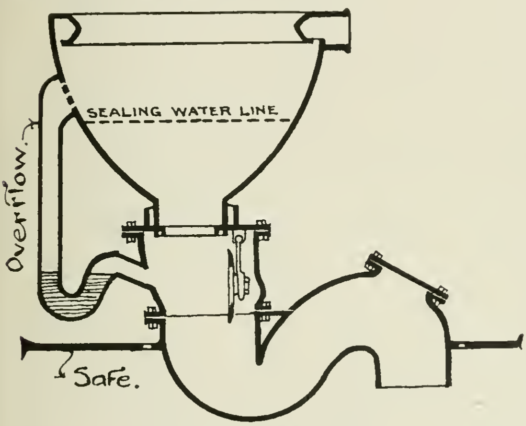


Fig. 131.—Valve closet.

Valve Closet (Fig. 131).—*Objections.*—1. There is a movable valve which often leaks, and is apt to get dirty.

2. The mechanism is complicated, and the apparatus expensive.

3. There is an overflow pipe from the basin to the neck of the syphon trap, or to the trap below water-level, which, in the event of the trap becoming unsealed, acts as a channel for the passage of foul gas into the house. In some valve closets efforts have been made to remedy this last defect, but the system as a whole is not a good one.

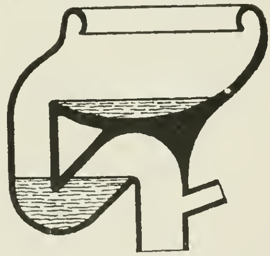


Fig. 132.—Wash-out closet.

Wash-out Closet (Fig. 132).—*Objections.*—1. It is apt to be noisy in flushing.

2. The lip of the retaining basin is apt to be too high, and so to prevent the speedy removal of the contents of the basin.

3. If an attempt to remedy this be made, the water in the basin is apt to be too shallow.

4. The inside of the syphon and the syphon-neck are partly hidden from view, and liable to become coated.

Wash-down Closet (*Long Hopper Form*) (Fig. 133).—*Objections.*—1. The basin is badly shaped and cannot be properly scoured, being far too long above water-level.

Short Hopper Form (Fig. 134).—1.—The fæces are not so open to inspection as in the other varieties. This is a medical and not a sanitary objection. It will thus be seen that the last-named type is the best. It is so because—

1. It is cheap.

2. It fulfils all the essentials of a good closet already mentioned. The full force of the flush acts directly on the trap water, there being no opposition

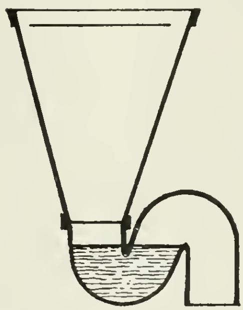


Fig. 133.—Long hopper closet.

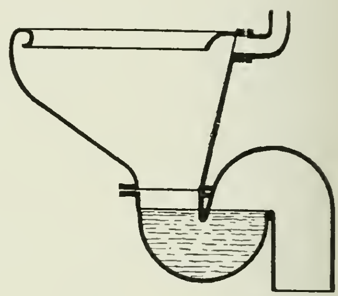


Fig. 134.—Short hopper or wash-down closet.

offered to the rush of water by any kind of retainer. There are numerous forms in the market which do not greatly differ from each other. It will be sufficient to indicate the general arrangement and construction of such an apparatus. The basin is made of glazed earthenware or vitro-porcelain, is short-sided, and so bent as to permit of proper scouring; while it is provided with a flushing rim. The top of the water seal fills up the lower part of the basin, so that the excreta drop directly into it, and the sides of the basin are not fouled. The bend of the syphon is raised off the floor by a small pedestal, which lessens the risk of fracture and ensures stability (Fig. 135).

The *Syphon Closet* is a modified form of wash-down closet, provided with a syphonic jet opening into the top of the down-pipe. By this contrivance a syphon action is started which empties the basin.

It is advisable to have a leaden safe or tray placed on the floor under the closet to protect the former from leakage or splashing. This safe should be turned up at the edges, and have a pipe passing from it through the house wall and opening free in the open air. The total depth of water in the trap should be about 7 in., that forming the water seal being 3 in. deep, and the part of the apparatus between the trap and the soil pipe should be as short as possible, and should be provided with a ventilating pipe passing to the outside air to prevent syphonage and to carry off any accumulation of sewer air between the trap and the soil-pipe (see Fig. 139). By syphonage is meant the sucking away of the water in the trap owing to the rush of liquid down the soil pipe. It is really an aspirating action. Instead of making the basin and trap in one piece, it is better, as in Moore's self-ventilating safety trap (Fig. 135),

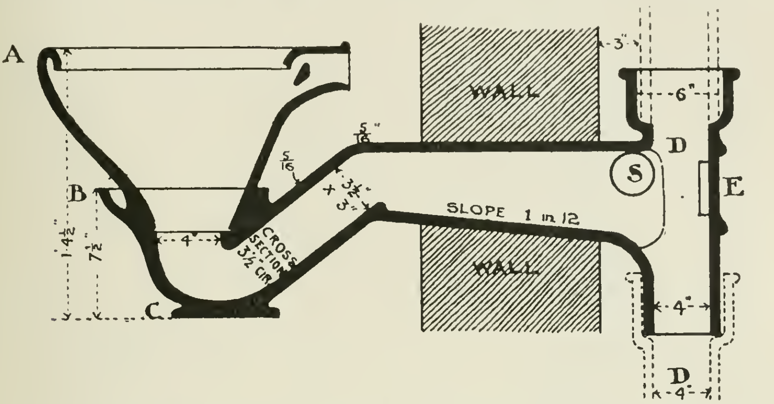


Fig. 135.—Colonel Moore's self-ventilating safety water-closet trap. *a*, Flushing rim. *b*, Junction of basin and trap. *c*, Pedestal. *d*, Soil pipe. *e*, Inspection eye-hole. *s*, Opening of antisyphonage pipe.

to have a joint between them, and to construct the trap and soil pipe of one piece, thus avoiding the ever-dangerous connection between these parts. The trap may be made of cast-iron, glazed internally, which is cheap and durable, and can be fixed to the basin by cement.

Connection with soil pipe.—A joint, as just stated, should be avoided, but when present it is most easily formed if the trap and soil pipe consist of the

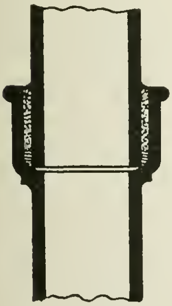


Fig. 136.—Caulked joint.

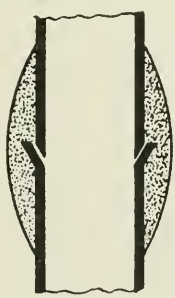


Fig. 137.—Wiped joint.

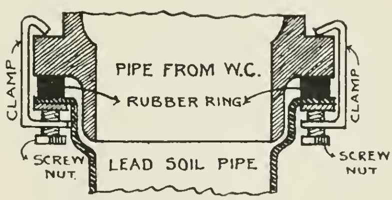


Fig. 138.—Clamped joint.

same material, be it cast-iron or lead. If of the former, a simple caulked lead joint (Fig. 136) is sufficient, the end of the trap pipe fitting inside the end of the soil pipe for a depth of at least 2 in., and the interval being filled in with lead and gaskin. If of the latter, a wiped, solder, or plumber's joint (Fig. 137) is used, formed by everting the edges of the soil pipe, and thrusting within it to a distance of from $\frac{1}{2}$ to $\frac{3}{4}$ in. the shaved end of the trap pipe. The adjacent external parts of each are scraped and greased, and finally solder is worked all over the scraped surfaces in the form of a strong encircling collar. If earthenware has to be attached to lead or iron, no joint is thoroughly satisfactory, but the best is got by means of clamps and india-rubber (Fig. 138). The rubber ring is compressed by screw clamps between the earthenware and the lead, the former being provided with a projection for the purpose. Such a joint requires frequent inspection, as rubber is perishable. A patent metallo-keramic joint, in which lead can be blended with earthenware by a special process, has more recently been invented. If such be used, one end of a lead pipe is usually united to the closet out-go, and its other end attached to the soil pipe by a wiped joint. Such an arrangement is very efficient, though somewhat expensive. It should be remembered that the pipe from the water-closet should get outside the house as quickly as possible.

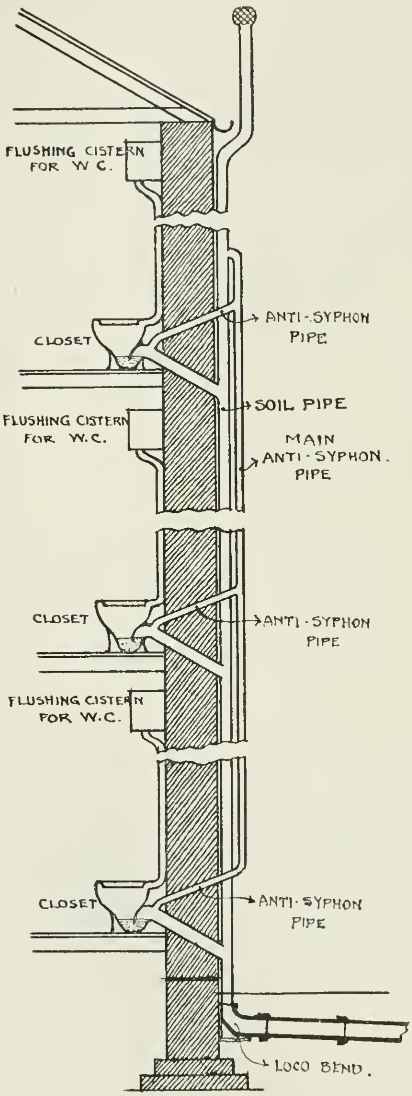


Fig. 139.—Soil pipe.

Cleansing of water-closet.—However efficiently a water-closet basin may be scoured by a water flush, it always requires to be properly cleaned out by a brush, the water being allowed to run during the process, and the brush being thrust down into the trap as far as possible and carried round the rim. The use of dilute acid, for example, oxalic, is to be recommended if the basin be foul or discoloured.

Soil pipe (Fig. 139).—The soil pipe, which may be defined as a lead or iron pipe conveying nothing but the effluent from water-closets, should not be more than 4 in. in diameter, and in the case of a single closet 3 in. suffices. It should be outside the house, and if of lead, should be protected from the direct rays of the sun. Above the spot where the pipe from the highest closet in the house joins it, the soil pipe must be carried up full-bore above the roof eaves as a ventilating pipe, and open free away from any window or chimney flue. Bends are to be avoided, but if present, should be of an "easy" angle. The top of the ventilating pipe may have a wire cage fitted on it to prevent birds building in it, but if so, the meshes ought to be narrow, as otherwise it favours nests. Sometimes the pipe is divided into two at the top and turned over on each side, but all such contrivances tend to lessen the desired aspirating effect of the wind and lessen the up-draught. Cowls designed to aid ventilation are doubtful advantages. As regards material, drawn lead is the best, but cast-iron coated with Angus Smith's varnish or glass enamel may be employed. Seamed lead is always to be condemned, as it is liable to corrosion and leaks, due to alterations in temperature. If of drawn lead, the pipe must be of uniform thickness, and the lead should weigh from 8 to 10 lb. per superficial ft. The leaden pipes are supported against the wall of the house by "ears" or "tacks" made of lead, which are nailed into the masonry, and are firmly in contact with the pipe on either side. Iron pipes are similarly supported by iron "lugs." The soil pipe, being very heavy, should be supported at its base. An iron standard may be used for this purpose. It is of greater importance to note that there should be no trap at the foot of a soil pipe, because it checks the flow of the effluent water and increases the difficulty of ventilating the soil pipe, which should have a current of air passing right up it, an air inlet being provided on the house side of the trap guarding the drain or sewer which it joins. At the foot of the house, where the soil pipe bends away towards the larger drain or sewer, it should be fashioned as shown in Fig. 140. No soil pipe should pass under a house if this can be avoided, but if such a course be absolutely necessary, the soil pipe should be embedded in concrete 6 in. thick, be at least 6 in. below the building, and be accessible at either end. The first break in continuity found in the soil pipe after it leaves the house is the aperture of the air inlet referred to above. Immediately beyond this, the syphon trap guarding the drain is found, which at its distal end has another ventilation opening designed to act as an outlet for accumulations of sewer gas in the drain. Both these openings and the syphon seal are combined in the well-known Buchan trap (Fig. 141) and other forms of ventilating, intercepting traps, such as Weaver's and Hellyer's (Figs. 142 and 143), which are constructed of glazed earthenware. Cregeen's patent air inlet (Fig. 144) is an earthenware box with a movable lid, which is solid in the centre immediately above the opening into the pipe, and thus prevents the entrance of dust and dirt. Towards its periphery

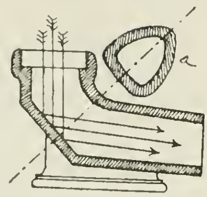


FIG. 140.—"Loco" deflector bend. *a*, Section.

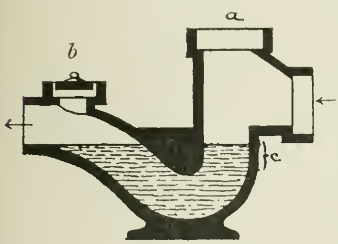


FIG. 141.—Buchan trap. *a*, air inlet. *b*, Inspection eye-hole. *c*, Extent of water seal.

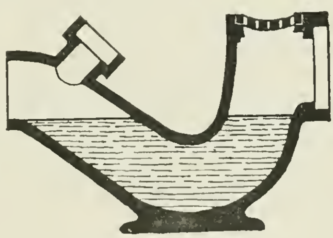


FIG. 142.—Weaver's trap.

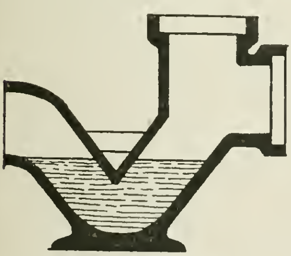


FIG. 143.—Hellyer's trap.

there are openings through which the air enters. A trap in this position should have a drop of from 3 to 6 in. from the soil-pipe entrance to the top of the water seal. The latter should be 3 in. deep, the air inlet 6 in. in diameter, and the outlet towards the drain from 4 to 6 in. in diameter, varying with the size of the drain or sewer. The outlet to the drain or sewer should be at least 3 in. lower than the inlet from the soil pipe. The trap should also be fitted with an eye-hole for inspection. Such an inspection inlet should never be placed directly above the syphon bend.

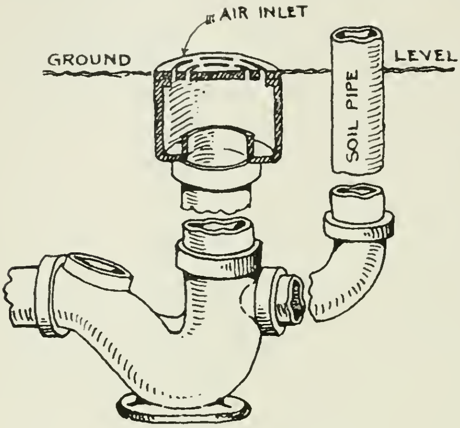


Fig. 144.—Cregeen's air inlet.

Jointing of trap and soil pipe.—The junction is effected by one of the methods already described, and the connection between the distal end of the trap and the town drain or sewer is made with cement or by means of a special junction piece which may be of terra-cotta. These remarks apply equally to a house drain, which is really a soil pipe conveying, in addition to the water-closet effluent, the waste water from baths and sinks, and it may be the rain-water. In this case, however, the trap may take the form of a man-hole chamber or disconnecting pit, a more costly arrangement (shown in Figs. 145 and 146), where the drain becomes an open earthenware channel running along the floor of the pit, and the inspection inlet acts also as a raking arm through which any obstruction can be cleared away. Should an earthenware house drain pass under a wall, there is danger from fracture, owing to settling of the wall, and it is necessary to arch the wall over it to prevent any pressure from weight.

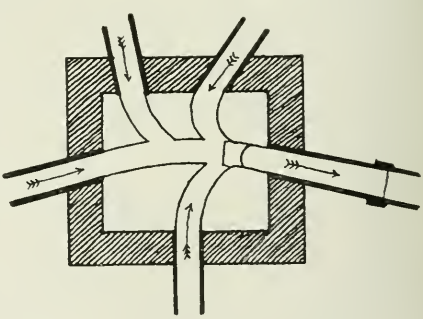


Fig. 145.

Having thus traced the soil pipe to the drain or sewer, it is necessary to revert for a moment to its connection with the water-closets as regards ventilation (see Fig. 139). It was stated that the ventilating pipe from the highest closet in a house might open directly into the upper part of the soil pipe. In the case of the other closets, their ventilating and antisyphonage pipes should pass to a special air shaft, which is the continuation upwards of the ventilating pipe of the lowest closet, and which opens into the upper part of the soil pipe above the place where it is joined by the exit pipe of the highest closet, or may itself open free like the soil pipe. If the soil pipe or house drain of the house under consideration joins a town drain or a sewer, the further consideration of the sewage journey is dealt with in the description of town drainage.

If, on the other hand, the house be isolated, we pass at once to the discussion of the ultimate fate of the soil pipe or house drain contents. These may pass into—

1. *A cesspool*, though other methods of disposal are preferable. A cesspool must be capacious, covered, water-tight, ventilated, a sufficient distance from any house, road, or water supply, emptied at regular intervals, and shut off from the house by means of a ventilating, intercepting trap on the pipe leading to it. The pit should be large enough to hold the sewage of several months, but its contents should be frequently pumped out, mixed with dry earth, and used as manure. A special pumping apparatus, such as Merryweather's, ought to be used. The cesspool is built of brick, faced with cement, and surrounded by puddle clay, and is closed above by a tightly-fitting man-hole cover. Ventilation is secured by means of the intercepting trap, where this is adjacent, or by special ventilating shafts fixed in the cesspool itself, one acting as an inlet, the other as an outlet. Many cesspools, however, are unprovided with means of ventilation, and act as anaerobic septic tanks, the sewage effecting its own purification (p. 385).

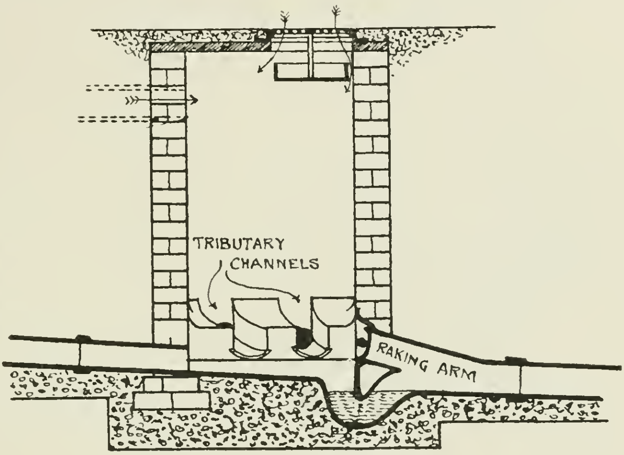


FIG. 146.

2. *An open ditch, watercourse, stream, or small pond.*—This method of disposal is to be condemned as being both insanitary and wasteful. A house may pass its sewage into a large navigable lake or river, or into the sea, but such methods, though often convenient, are also wasteful.

3. *The soil.* — Subsoil irrigation, or intermittent upward or downward filtration, if suitable ground and sufficient fall can be obtained, are excellent methods of disposal, rendering the sewage innocuous, and, in some instances, taking advantage of its manurial value. These processes are considered in connection with town sewage, and it is sufficient here to state that, for a house, loosely-laid agricultural tiles or pipes 2 in. in diameter placed about 1 ft. underground are employed. These pipes should be 6 ft. apart, their ends should rest on half-pipes as supports, and the open joints should be covered by pieces of half-pipe to prevent the entry of earth. An air vent is required for these subsoil drains. They should be flushed by grease or flushing tanks, and may advantageously pass to a vegetable garden. One drawback to such a process is the chance of ill effects arising if the sewage should become infected with enteric bacilli or cholera spirilla, while the pipes require cleaning and relaying once every few years. Further, there is a

difficulty in securing a uniform distribution of the sewage. In any case the sewage must be conveyed well away from the house in a properly laid and constructed pipe before it passes along the subsoil pipes. If necessary, deep drainage pipes may be laid to prevent the soil becoming swampy and getting clogged, by facilitating removal of the purified effluent water to the nearest stream or ditch.

2. **Waste waters.**—By waste waters are meant the effluents from baths, wash-hand basins, sinks, wash-tubs, and slop waters generally. Rain-water also comes under this category.

A bath should be provided with a safe or tray of lead placed underneath it and turned up at the edges. This safe should have a pipe passing from it through the house wall and opening free in the open air. The waste pipe from the bath must be $1\frac{1}{2}$ to 2 in. in diameter, trapped and ventilated, and should pass through the house wall as quickly as possible and open into a main waste pipe.

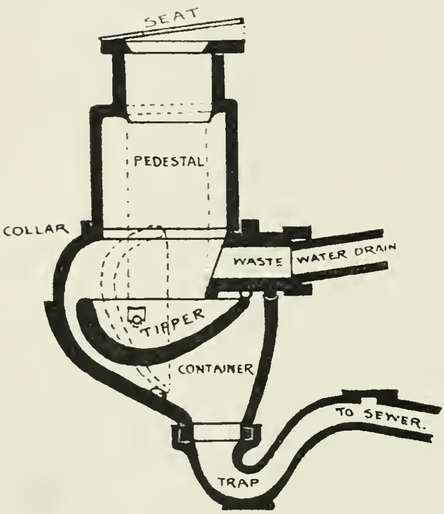


Fig. 147.—Waste water-closet.

The waste pipe from wash-hand basins should be 1 to $1\frac{1}{4}$ in. in diameter, and should also be trapped and ventilated immediately under the basin, and pass into the main waste pipe. The stain which forms on porcelain baths and basins may be readily got rid off by scrubbing with powdered chalk and a few drops of ammonia.

There are slop, scullery, and pantry sinks. When a house contains wash-down closets with hinged seats, there is no necessity for slop sinks. Valve closets must not be used as slop sinks, because when the extra water is thrown into them it passes down the overflow pipe before the handle is raised, and foul odours proceed from the fouled pipe. The sanitary precautions mentioned in the case of water-closets apply equally to slop sinks, which are best made of stoneware or iron, and, in addition, the outlet from the sink should be secured by a movable screen or grating to prevent blocking by brushes, etc. The waste pipe from the slop sink may pass either into the soil pipe like a water-closet out-go, or into the main waste pipe. As urine frequently forms a large part of the slop waters, the former is the preferable method, and, if employed, the trap should be of cast-iron or lead, so that it may be easily jointed to the soil pipe.

What is known as the waste water-closet (Fig. 147) is commonly found in the lower class houses of manufacturing towns in the north of England. A tipper receives both the excreta and the waste water, and when full it tips over and discharges its contents into the syphon trap placed below it, the waste waters thus taking the place of the clean water in ordinary water-closets. The system is a bad one, as the sewage is very strong and foul, while even in the best constructed varieties, the long length of pedestal from seat to tipper is very apt to become dirty and offensive.

Scullery sinks are of stoneware or iron, pantry sinks of wood lined with lead, and their arrangements are conformable with those of baths. The main

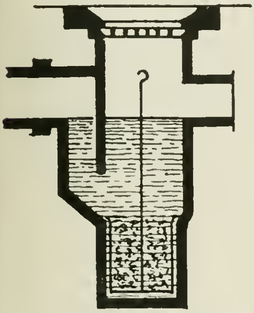


FIG. 148.—Bucket trap.

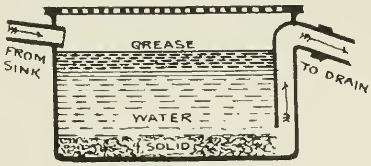


FIG. 149.—Grease trap.

waste-water pipe, like the soil pipe, should be carried up full-bore above the level of the roof eaves and open free for purposes of ventilation. Below, it should open free in the open air over a channel leading to a trapped gully at least 18 in. distant. The trap may be provided with a movable bucket (Fig. 148) into which sediment of any kind falls, and can be removed at intervals. A flange surrounds the top of the bucket so that it fits the trap walls accurately, and dirt does not fall down to the foot of the trap as the bucket is being removed. Grease may be got rid off by a grease trap (Fig. 149), which either serves for a sudden flush and the breaking up and carrying away of the floating scum down the pipe, or, as in the "loco" grease box or Hellyer's grease intercepting tank (Fig. 150), permits of the grease accumulating and being removed, as in the bucket method for sediment.

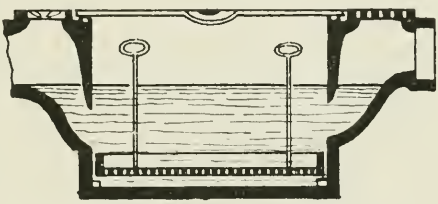


FIG. 150.—Hellyer's grease intercepting tank.

Only syphon (S-shaped) traps or anti-D traps are admissible. Bell (Fig. 151), Antill (Fig. 152), Dipstone (Fig. 153), and D (Fig. 154) traps are to be condemned wherever found. Syphon traps should be self-cleansing, but require an access-screw plug at the bottom of the lower bend. Anti-D traps (Fig. 129, p. 352), which have the part forming the water seal narrower than the in-go, are very effective in preventing syphonage. Bell traps are met with in two forms. They are objectionable because—(1) The water seal is too shallow, being only $\frac{3}{8}$ in. Thus evaporation often renders the trap useless. (2) They are easily choked, owing to the small space between the

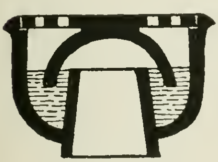


FIG. 151.—Bell trap.

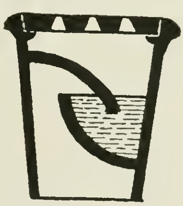


FIG. 152.—Antill's trap.

bell and the waste pipe. (3) When the grating is removed the waste pipe is untrapped. (4) The bell is easily broken in the first form, and may

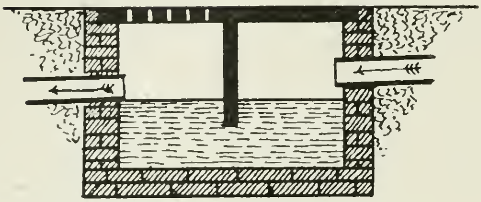


Fig. 153.—Dipstone trap.

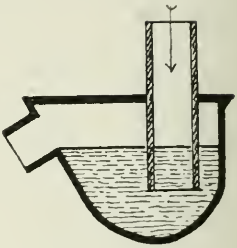


Fig. 154.—D trap.

even be too short to reach the water at all. (5) They are difficult to clean properly.

The Antill trap (Fig. 152) has the same disadvantages, with the exception of No. 3.

The Dipstone or Mason's trap (Fig. 153) is most obnoxious, because—(1) The unventilated cover is rarely air-tight; (2) it is not self-cleansing, and becomes filled with deposit; (3) it is not easily cleaned; (4) it frequently leaks.

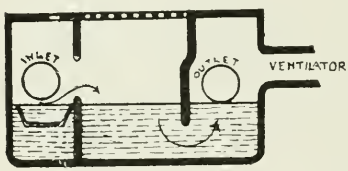


Fig. 155.—Mansergh trap.

The D trap (Fig. 154) is of faulty construction, and is not self-cleansing.

The Mansergh trap is a better variety (Fig. 155).

Having passed the trap, the waste waters flow along to join the main house drain or the sewer.

Flushing tanks are useful both in the case of sewage and waste waters, and are best suited for use with iron pipes, as too frequent flush is apt to damage those of earthenware. They may be automatic or non-automatic in action, and in the case of a house may be supplied from stored ablution-, or rain-water. A flush tank is placed at the head of the drain to be flushed, and the discharge must be copious, sudden, and powerful, run full-bore and sweep all before it. The amount of water depends on the gradient and the size of the pipe to be flushed. If automatic, the action is one due to syphonage, as in Field's flushing tank (Fig. 156), which acts excellently when clean water is used. It consists of a tank supplied by a water-tap and pierced at the bottom by a vertical tube rising nearly to the top of the tank, and below passing into a small chamber, in which it dips under water, and from which passes a pipe to the drain. This vertical tube is bevelled at the top and covered over by an inverted tube, which does not quite reach the bottom of the tank, and thus forms the syphon. When the water reaches the bevelled top, rising between the tube and the covering tube, it drips over and falls clear down the vertical

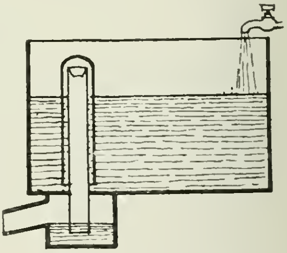


Fig. 156.—Flushing tank.

pipe, extracting air with it. Consequently a partial vacuum forms, and this ultimately results in the production of syphon action and the emptying of the tank. A small air-hole in the inverted tube regulates the amount of discharge. Adam's flushing gully (Fig. 157), in which no vacuum formation is required, works well with either clean or dirty water, the action depending merely on the height to which water rises in the tank.

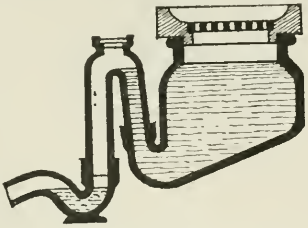


Fig. 157.—Adam's flushing gully.

Rain-water is collected from the roof in rhones or gutters, which should be sloped in the direction of the rain-water down pipes. The down pipes are of cast-iron, and their joints are caulked with tow and filled in with red or white lead. This jointing is bad when the rain is intended to serve as a water supply. The down pipes must never open into any soil pipe or drain, otherwise they act as conductors for offensive gases, but should discharge into the open air over a channel leading to the nearest trapped gully. In a town house the rain may then join the ordinary waste waters in the waste drain, or be conveyed in special pipes in accordance as there is a combined or separate system of town drainage (see p. 376).

II. *DRY METHOD.*

1. **Sewage.**—The dry method for the removal of sewage is termed the system of *conservancy* or *interception.*

Privies or Middens.—As originally devised, the midden was merely a hole dug in the ground, an omnium gatherum of all manner of filth. Even in its most improved form the privy midden is not a savoury object. The privy should be well away from the house and from any water supply; it must be roofed, ventilated, and have a floor raised above the ground-level and sloping towards the door. The midden pit should have impermeable walls, and a floor made of brick set in cement, and must be protected from rain and snow. It must not be too large, a capacity of 8 cubic ft. sufficing, otherwise the contents are allowed to lie too long. The floor of this receptacle should be smooth, and above the level of the adjoining ground. Means of access must be provided for scavenging, which should be done every week, and at a time when no nuisance will be produced. In some privies the fæces are unmixed with ashes, but it is better to have these latter added, as they help to dry the deposit. They may be thrown in on the fæces by raising the seat lid, or down a shoot by pulling up a handle. They may have been previously sifted by means of a grating covering a pit under the kitchen fireplace. They may also be sifted in the closet itself (Fig. 158).

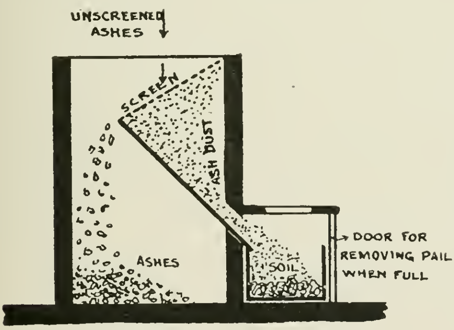


Fig. 158.—Cinder-sifting ash-closet.

Morell's Riddled Ash System.—This is a dry closet with a permanent receptacle wherein sifted ashes fall upon the excreta, the larger ashes being automatically rejected.

Earth Closets (Moule's system).—By automatic action or by raising a handle, earth is added to the deposit each time the closet is used. One and a half lb. of clear dry sifted earth are thrown into the receptacle, which may be movable or non-movable. Good loamy soil or brick earth is the best, and acts as an excellent deodorant and absorbent of both fæces and paper. This system acts well for isolated houses. The earth compost can be dried and used again and again, finally being restored to the land, having altered surprisingly little in the process.

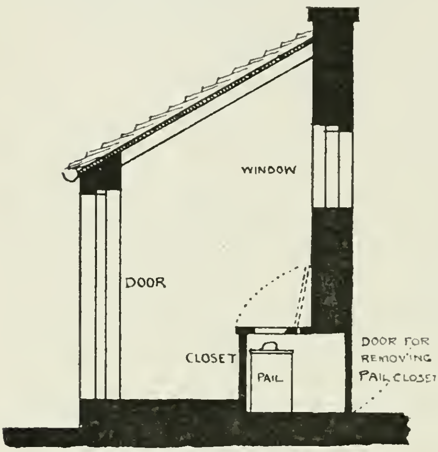


Fig. 159.—Pail closet.

Charcoal Closets.—Charcoal made from peat or seaweed dries and deodorises excreta, and is very economical.

Pail System (Fig. 159).—Galvanised iron pails or wooden tubs with well-fitting lids are a modification of the midden system. Their capacity should not exceed 2 cubic ft. Frequent removal and thorough cleansing is required. Ashes and household refuse may be removed in the pails as well as excreta. If pail contents are intended for manure, the fewer ashes the better.

Goux System. — Buckets or pails are lined with some absorbent and deodorant material, such as dry peat, or sawdust, or soot. Only urine and fæces should be admitted.

In all these systems the contents of the receptacles may be collected and removed by the sanitary authorities in the case of towns, and their further disposal is considered in due course. In the case of a single house, they are applied directly to the land, care being taken that they are first of all mixed with dry earth, and then used as manure at a distance from any house, road, or water supply.

2. **Waste waters.**—In a house served by the dry method, the slop waters pass, as in the wet method, through a gully trap and along drains. These may simply communicate with holes dug in the garden, or with cesspools, streams, ditches, etc. Wherever possible, it is better to utilise them for subsoil irrigation.

B. TOWNS.

I. *DRY METHOD.*

(*a*) **Sewage.**—The conservancy system is very much inferior to the water-carriage system, both as a sanitary measure and on account of the expense involved by the scavenging. Further, the less scavenging the less expense, and hence a temptation to the sanitary authority to be remiss in its duty. True, the manurial value of the refuse is high, but the price obtained rarely covers the expense of removal. The pail system alone is suitable for towns, as it is impossible to provide and store the large quantities of suitable earth required for earth closets, which, however, constitute a better method. The pails should be of wood, tarred oak, or it may be, as at Rochdale, petroleum casks cut in two, restaved, hooped, and provided with air-tight covers. They are 18 in. in diameter at the top, 15 in. at the bottom, and 16 in. deep. Such pails must be removed in partitioned and covered carts at least once a week, and replaced by clean ones. The full pails are taken to a central building and their contents tipped into a tank, to which sulphuric or hydrochloric acid is added to fix the valuable ammonia. The moisture is evaporated by treatment of the superjacent fluids of the sludge by steam and drying fans in iron cylinders, and a dry "poudrette" results, which has a ready sale as a manure. The heat required for the drying is obtained from the combustion of house and street refuse, and so fuel is saved. The pails are thoroughly cleaned and disinfected before being returned (Rochdale). The ashes contained in the filth of any privy middens which may exist in the town render this process inapplicable, and such refuse is best sent away out into the country to be spread upon land. The transit is cheap if a canal be in the proximity. If the Goux system be employed, the absorbent lining is replaced each time after the pails are emptied, and is compressed into shape by means of a mould (Halifax). The use of cheap charcoal has its advantages, as the mixture of charcoal, fæces, and urine can be recarbonised in retorts, and the carbon again employed; while the ammoniacal products obtained are valuable as manure.

(*b*) **Waste waters.**—The waste waters of a "conservancy" town require to be disposed of by a system of sewerage which does not differ from that required when the excreta are removed by the water-carriage system.

II. *WET METHOD.*

(*a*) **Sewage.**—The water-carriage system in towns necessitates a system of sewers which vary in size according to the volume of sewage to be dealt with, and according as they are utilised or not for the conveyance of rain and surface waters. When sewage, slop waters, trade effluents, rain, and surface waters are all conveyed together in one set of pipes, the system is termed *combined*. When one set of pipes is set aside for sewage, slop waters, and trade effluents, and another for rain and surface waters, it is called *separate*. In addition, provision has always to be made for the drainage of the subsoil in which the pipes lie. The water-closet system of houses has been discussed, and the effluent from the closets has been traced as far as the junction of the main house drain with the sewer. Before considering how this junction is effected, how sewers are made and laid, and the journey of their contents, certain points as to special and public water-closets, other public conveniences, and house drains in towns, fall to be discussed.

The *Scientia Closet*, while it might be employed in an isolated house, is specially adapted for large buildings in towns, especially if these have been fitted with bad forms of water-closets, and a change is required, as it can be erected without much structural alteration in the building and at a moderate cost. It conforms to the best type of wash-down closet, combined with a system of ventilation whereby all odours are at once removed by means of a ventilating shaft, an air current constantly passing over the basin, and yet not giving rise to any draught. Associated with it there are urinal and lavatory fittings, a housemaid's draw-water, and a large slop sink.

Public Water-closets or Latrines.—Where a number of closets are ranged alongside each other, they may discharge into a long, open trough placed below them, having a flushing tank at the upper end, and a grating and trap at the lower end. The trough (Fig. 160), which should be semicircular, may be of iron or stoneware, and the excreta should drop directly into the water it contains, this water being retained in the trough by means of a weir placed above the trap. Such an arrangement is suitable for schools, factories, workmen's dwellings, and the poorer districts of large towns, but it has the following disadvantages:—

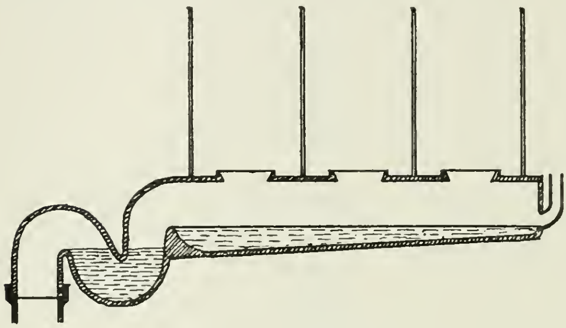


Fig. 160.—Trough closet.

1. The large, open water surface containing excreta, removed only by the flush, constitutes an offence, and possibly a danger.

2. There is an air communication between the seats, and consequently a distribution of any evil odour.

3. Efficient flushing is difficult, owing to the large quantity of trough water upon which the flush has to operate.

It is better to have a closed iron pipe instead of the trough, and to make the flush pass first through the closets, which are glazed stoneware or iron basins. The trap is better placed at the centre of the system than at the end of the pipe, both ends of the pipe sloping gently towards it (Fig. 161).

Urinals.—There are three classes—stall, trough, and basin. The first two are most applicable for outside use, the last for use inside buildings.

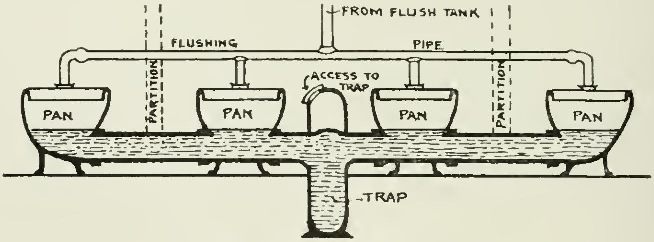


Fig. 161.—Improved trough closet.

Stall urinals are made of slate, enamelled slate, white enamelled fireclay, glazed earthenware, or enamelled cast-iron. The material should be unabsorbent, incorrodible, unacted upon by uric acid, and the supply pipe should be of brass, copper, or zinc. Corners are to be avoided, and an automatic flush must be provided. The floor should slope towards the channel, which ought to be trapped at its lower end. The diameter of the waste pipe should not be so great as to prevent proper flushing.

Trough urinals.—In these the urine is passed into a trough containing water, retained in it by a weir, and cleansed at intervals by an automatic flush tank.

Basin urinals.—They are usually made of white glazed porcelain, and should be as small as possible. The front edge should be narrow and bevelled, and have a projecting lip, while the whole basin should be provided with a flushing rim. Where the water supply is small, a certain quantity should be retained in the basin to prevent ammoniacal smells. The advantage of the basin over the stall urinal, especially for indoor use, is the small area fouled. It is well to have an accessible down-pipe, so that, as it is often the source of bad smell, it can be readily cleaned.

Urinettes.—These are urinals for women, and should be provided as plentifully as for men, and without charge. It seems ridiculous that such sanitary necessities should be left to the private enterprise of confectioners, drapers, and railway companies. Urinettes are provided with curtained compartments, containing small basins resembling water-closets, flushed by an automatic tank.

Public Conveniences are frequently placed underground, and if so, must be specially well lighted and ventilated. They contain water-closets, urinals, urinettes, and lavatories, and may be ventilated through a lamp-post, by means of a fan driven by water. Sunlight is better than artificial light.

In towns it may be necessary, owing to limited space, to place traps at the foot of soil pipes instead of in the course of the house drains, and these should always be of the nature of ventilating-interceptors, and have deflector bends. Sooner or later, however, smell results. If main house drains unite before entering the sewer, there should be a disconnecting chamber, such as has already been partially described, at the point of junction, and the junctions must not be at right angles, but in the direction of the sewage flow. The soffits or upper circumferes of the pipes must be at the same level. The disconnecting chamber is built of bricks, set in and faced with cement, and it has a concrete sloping floor, and a grated ventilating cover.

Glazed stoneware is the best material for house drains. It is a good clay, with powdered flints well burned to vitrification and salt-glazed in a kiln, whereby a silicate of soda is formed on the surface of the pipe. This is a true glass, as the clay contains sesqui-oxide of iron. A stoneware pipe is circular in section, made in lengths of from 2 to 3 ft., and has a faucit, or receiving, and a spigot, or entering, end. The faucit is 3 in. deep, and must be made in one piece with the pipe. The pipe must be of uniform thickness, straight, smooth, and true in section. The thickness, which is tested by callipers, should bear a certain relation to the diameter, being one-sixth to one-twelfth of the diameter. Thus a 3-in. pipe should be $\frac{1}{2}$ in. thick, an 18-in. pipe $1\frac{3}{8}$ in. thick. The pipe must be non-porous, as, apart from danger of leakage, frost seriously affects a porous pipe. It should withstand a pressure of 25 ft. of water without leaking, and give out a good ringing note when struck by a hammer. On fracture it should appear homogeneous. Jointing is performed by thrusting the spigot into the faucit, and filling up the space with (*a*) puddle clay covered by Portland cement, or (*b*) asphalt, a collar of Portland cement being applied externally, or (*c*) gaskin and cement may be used with the same precaution, or (*d*) Portland cement alone. It is important to see that the joint is perfectly smooth inside, and if the pipe is carried through shrubberies it must be imbedded in concrete, otherwise the thirsty bush and tree roots will find their way through the joints into the pipe interior.

Special joints.—The spigot may be grooved so as to screw into the faucit, or may be tongued, or rest on projections inside the faucit, thus keeping the inverts true, the whole being rendered firm with cement. The spigot may be coated with bituminous material, which may or may not be also applied to the faucit, cement being used as a fixing agent. Where one pipe meets another, the junction must be in the direction of the sewage flow, be V-shaped, and be effected by the interposition of special junctions, bends, or taper pipes of the same material, as a pipe should never be cut. Fig. 162 shows the proper line of junction between a receiving and tributary pipe. Covered inspection eye-holes in the soffit are useful.

Pipes must be laid on true beds, a special recess being made to receive the faucit, which should point uphill, and support the spigot of the pipe above. If the pipes rest in unstable ground, they must either be specially thick or be protected by a concrete coating 4 in. thick. Stoneware pipes of a greater diameter than 18 in. should not be used as drains. For exportation to places where skilled labour is absent, or where stoneware cannot be got, pipes are made in small, grooved, and tongued segments, which can easily be fitted together, and then payed over by liquid Portland cement. House drains should have a fall of from 1 in 30 to 1 in 60, depending on the size of the pipes. The general rule is that the fall should be ten times the diameter of the pipe. The velocity in house drains varies from 3 to $4\frac{1}{2}$ ft. per second, in accordance as the pipe is running one-fourth or two-thirds full. If the sewers are liable to flooding, tide valves may be placed at the junction of the drains with the sewers, to prevent back-flow along the former.

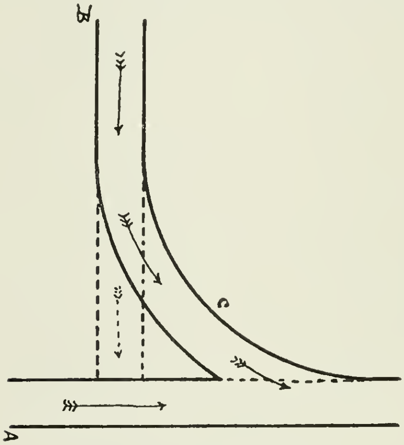


Fig. 162.—Junction of drains.

A new material for drain pipes is mill-board specially prepared. It is said to be very suitable for chemical works, as it is little affected by the effluent from such works.

Sewers.—These may be constructed of—(1) silicated stone, (2) brickwork, (3) concrete, (4) iron.

Course and Arrangement.—In applying a sewerage scheme to a district, it is important to note its geological characters, take advantage of the valleys, and lay the sewers as straight as possible to the outfalls, unless such a proceeding involves very heavy expense. The gradient must be sufficient to keep up sufficient flow, notwithstanding retardation due to curves and junctions. The sewers in a town are usually laid along the streets, and, where possible, in such a position as enables the house drains to pass directly into them without coursing under the buildings. At all junctions of subsidiary or main sewers, and wherever direction is changed, there should be a man-hole, lamp-hole, or ventilator, preferably the first-named, and all sewers must be ventilated, and, if necessary, flushed. Tributary sewers must open into the main sewer obliquely in the direction of the sewage flow, and must discharge into it with a velocity equal to that in the receiving sewer. The invert or bottom part of the smaller sewer should be as much above that of the receiving sewer as the differences in their sectional diameters. The liability to the production of a backwater is thus avoided, and the velocity is slightly increased. Sewers should run straight from point to point; and in towns where there are differences of level, great expense is avoided by putting in intercepting sewers, which prevent the lower parts of the town being flooded with sewage and storm waters, and the upper part being saturated with drain effluvia. These intercepting sewers run parallel to the line of the valleys across the slope, and carry off the drainage at the different levels, thus reducing the number of outfalls. In steep streets, or where a sewer on a high level must descend rapidly to join a sewer at a lower level, the direct fall is obviated by means of a "ramp," or by syphon drops. A "ramp" is a series of steps, something in the nature of a tumbling bay.

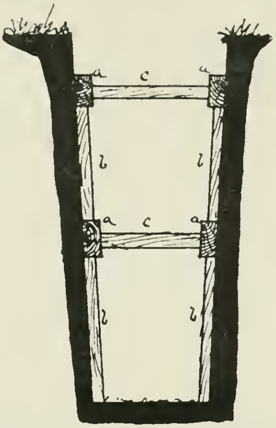


FIG. 163.—*a*, Wales. *b*, Props. *c*, Struts.

PREPARATION OF GROUND.—A trench is dug of such a depth as to permit of the house basements being drained, and to guard against the effects of frost and heavy traffic. If the ground be very unstable, the sides of the trench should be cut in the form of steps, or may require to be supported by timbers. All that may be necessary is the method of "wales," "struts," and "props" (Fig. 163); wales running along the sides of the trench, props passing up the sides and supporting them, and struts crossing the trench from wale to wale. If, however, the ground be very bad, poling boards may be inserted as aids to the wales and props (Fig. 164), or the whole sides of the trench may be lined with boarding, called sheet piling, bound together by binding struts (Fig. 165). When the sewer has to pass through tunnels, it is advisable to erect a complete framework; and when a good foundation cannot be secured, the sewer may be built on arches of brick and concrete, whose piers reach down to solid ground, or be placed on a bedding of concrete 4 to 6 in. thick. If on a rock foundation, sewers should be bedded in soft material, such as fine gravel or puddle clay. To secure a true gradient, sets of sight rails are erected above the trench, at such a relative height as to represent the slope required in the pipe between the points at which the sight rails are fixed. A rod of appropriate length, whose head is moved along the line of sight from one rail to another, will with its lower end indicate the required depth of the trench at each point between the sight rails.

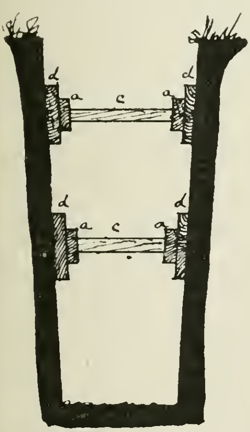


FIG. 164.—*a*, Wales. *c*, Struts. *d*, Poling boards.

LAYING AND MATERIALS.—(*a*) *Silicated stone.*—Such pipes are machine-made stoneware, and receive a bath of silicate of soda. They do not warp with heat, do not leak, are not liable to longitudinal fracture, and are easily jointed, while the inside of the pipe so formed is perfectly true and smooth. The one section fits into the other, and the joint is secured by Portland cement. While an earthenware pipe must not be more than 18 in. in diameter, this form is used up to 42 in. They are laid at a minimum depth of 5 ft. where subjected to traffic pressure, and in any case must be buried at a distance from the surface equal to twice their diameter. As regards the trench, they are laid from below upwards, the faucits facing the slope. An ingenious device, called "a badger," is used for smoothing the joints internally and removing excess of cement.

(*b*) *Brickwork.*—Sewers made of brick are circular or egg-shaped. Purpose-made bricks of good quality are essential, and any variety of these is admissible save for the invert, which, if of brick, must be built of blue Staffordshire bricks. The invert, however, may be composed of terra-cotta, concrete, or glazed stoneware. A brick invert is fashioned upside down upon a wooden mould, and is supported at the sides by flaps held together above by a clamp. Once the invert is completed, the clamp is removed and the flaps fall apart, allowing the invert to be removed from the mould and fitted into its bed in the trench. The main body of the sewer is then built upon the invert. The thickness of the brickwork required depends on the depth of the trench in feet (d), and the radius of the sewer in feet (r). It may be found from the formula $\frac{dr}{100}$ = the thickness in feet of the brickwork required.

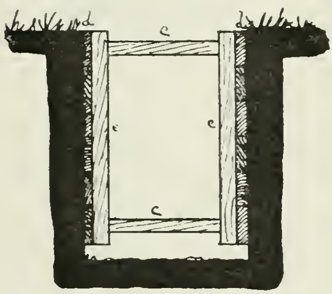


FIG. 165.—*c*, Struts. *d*, Poling boards. *e*, Sheet piling.

When a brick sewer consists of more than one ring of bricks, the joints must not be opposite each other, in fact the usual rules for brick-laying must be carried out in their entirety. If an egg-shaped sewer is to be built, a timber frame, having the shape of the proposed sewer and covered with lagging boards, is erected, round which the bricks are built, the lagging and frame being removed from the interior when the portion of the sewer is completed. Sewers are made circular when the flow is large and more or less uniform. Such a shape is easy of construction, strong and cheap. When the flow is irregular in quantity, an oval or egg-shaped variety has the advantage of maintaining a greater velocity with the minimum quantity of sewage.

In such a sewer the maximum transverse diameter is two-thirds of the vertical. In drawing the section of an egg-shaped sewer, the shape is obtained by combining the arcs of four circles, thus (Fig. 166) :—A vertical line AB is drawn to scale to represent the height of the sewer, and is divided into three equal parts, AC, CD, and DB. Through C draw a line EF at right angles to AB, and of such a length that CE and CF are equal to one another and to AC. Produce CE and CF to G and H, making EG and FH equal to CE and CF. Bisect DB at I. With centre C and radius CA describe a semicircle on the diameter EF. With centre I and radius IB describe an arc passing through B. With centres G and H describe arcs of circles having radii GF and HE and passing through E and F, thus connecting the arcs previously made, and showing with them the outline of the sewer. The radii of the invert, crown, and sides bear the ratios of 1, 2, and 6. In a large system of sewers numerous man-holes are required, one occurring about every 100 yds., and being supplemented by intervening lamp-holes, down which a light can be passed into the interior of the sewer, and when in situ viewed from the man-hole on either side. The man-hole covers must be air-tight, or the man-hole must be properly ventilated. Its sides are constructed of brick, set in cement or rock concrete, and its floor is composed of brick rendered with Portland cement, or cement alone along with white enamelled channels.

(*c*) *Concrete*.—When sewers are entirely made of concrete, it should consist of 1 part Portland cement to 2 parts of sand and 3 of small broken stones. A good foundation is essential; in bad ground the concrete sewer is laid on a broad base of concrete. The thickness of such a sewer is much the same as if the materials used were bricks. The trench must be dry when the sewer is built, so that the concrete will set properly. The building is done round a "template" frame, as in the case of the brick sewer, and the lagging must be greased to prevent the concrete adhering to it. It is necessary that the inside of the sewer should be "pargetted," *i.e.* coated with Portland cement and a little sand to render it smooth.

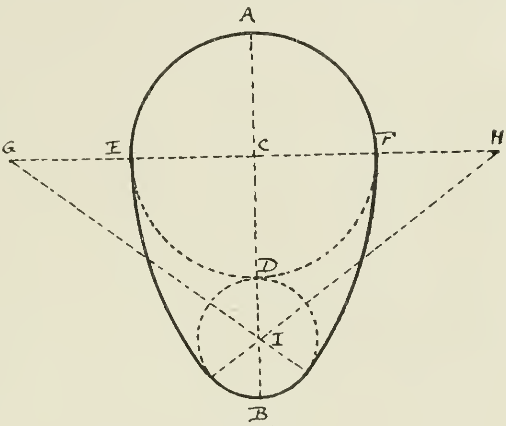


FIG. 166.

(*d*) *Iron*.—Large cast-iron pipes make exceedingly good sewers, though they are expensive. The metal must be homogeneous and of uniform thickness throughout, and the pipe should be capable of withstanding a head of 200 ft. of water. They do not require to have such a large diameter as the stoneware or brick sewers. They are coated with Angus Smith's varnish or by the Barff process, and are specially suitable where sewers are exposed to much pressure. Wrought-iron pipes are used in the form of inverted syphons where sewers have to pass a river which cannot be bridged at the level of transit. The pipes may be laid on the river bed or pass underneath it, and there should be a man-hole in each bank. The descending arm may be provided with a ventilating pipe, and a flushing tank in the proximal man-hole is useful. The arrangement may be such that a flat piece of piping follows the bed of the stream, connected at either end with sloping uprights. To prevent deposit in the flat piece, a chain, which can stir up its contents, may be passed from one man-hole to the other. Such syphons should not convey storm waters, the strain being too great, and these storm waters may be run into the river. The syphon principle is also applicable where valleys have to be crossed. Small sewers require a greater inclination than large ones, but the latter need a greater volume of water to maintain a proper velocity. A greater fall is necessary in brick drains than in pipe sewers. The fall for an average-sized sewer is about 1 in 800, the velocity $2\frac{1}{2}$ ft. per second. In sewers these numbers range from 1 in 250 to 1 in 5000, and from 4 to 2 ft. per second.

Pressure on Sewers.—Sewers must resist—(1) Vertical pressure, due to the weight of the superincumbent earth. This varies with the character of the soil and the depth of the sewers below ground. The egg-shaped sewer strongly resists pressure in this direction, its resistance being analogous to that offered by an egg pressed at each end, or an oval calculus grasped at its extremities by a lithotrite.

(2) Lateral pressure, due to the earth on the sides of the sewer after the soil has settled into position. It also varies according to the nature of the soil and to the angle at which the pressure is exerted.

(3) Intermittent pressure, of the nature of shock, as results from heavy traffic passing overhead, ground subsidence, earthquake, etc.

Refilling of Trench.—The lighter material is thrown in first, so that it fits closely round the tube. When the latter is covered to a depth of 2 ft., the successive layers of earth should be rammed down.

Ventilation.—All sewers must be ventilated to get rid of the noxious sewer gas which tends specially to accumulate at both ends of a sewage system. A rush of sewage tends to force the air in the sewer before it and drive it up through the traps of tributary drains, and ventilation is intended to obviate this danger, and also to prevent the gas rising to the higher parts of the system, and there gaining entrance to houses. Sewers should be ventilated every 100 yds., and at smaller intervals in the lower levels and where the gradient is steep.

Air currents are produced in sewers by—(1) The sewage flow and the rise and fall of the sewage tide.

(2) The direction and force of the wind. The outfall may be exposed to the prevailing wind, or wind may blow across the outfall or any man-hole or other opening, thus producing an aspirating action.

(3) The interchange constantly going on between the air in the sewer and the atmospheric air, and dependent on differences in their temperature, and on variations in pressure.

(4) Floods and flushings, especially if the latter be of hot water, or if a hot flush is followed by a cold one.

The object of ventilation is so to control these various factors as to regulate the time and place of the discharge of sewer air and to dilute its noxious constituents.

Methods.—(*a*) Man-holes, lamp-holes, and special air shafts with perforated covers, having trays below them to catch dirt and débris. (*b*) Air shafts connected with pipes passing up house walls to discharge above the roofs, or conducted to lamp-posts. These have not proved a success, and no pipe from a public sewer should be fixed to a dwelling-house, or open anywhere near a window or door. (*c*) Long shafts connected with furnaces. The action, however, is confined to the part of the sewer nearest the furnace, and is useless for a ramifying system. It finds its best scope in ventilating long outfall sewers without connections. (*d*) Extraction fans. (*e*) Extraction shafts with water passing down them to absorb the gas. (*f*) Special ventilation to lamp-posts, the gas light feeding on the sewer air and thus rendering it innocuous. (*g*) The use of absorbents and disinfectants employed in the ventilating shafts. Thus charcoal, asbestos, and various chemicals have all been employed, but their value is doubtful. (*h*) Shone and Ault's system, which consists of a special inlet shaft at the highest man-hole, and outlet shafts at the lower man-holes, a current of fresh air being drawn along the sewer by means of the escape of compressed air which may or may not be used to force on the sewage. It is said to be efficient and inexpensive.

The above aim solely at the removal of the sewer gas as far as the interior of the sewer is concerned, but efforts have been directed to rendering it innocuous in situ by means of charcoal, dry earth, permanganate of potash, chlorine, galvanic action as an ozoniser, etc.

Reeve's method.—This consists in the evolution of nascent oxygen by the action of sulphuric acid on manganate of soda, the process taking place within the man-holes. Water in the form of a fine spray carries down the oxygen, and purifies the gases coming up the shaft. It is used in parts of Edinburgh and elsewhere, but can be nothing more than a deodorant process.

A sewer in the form of an open channel possesses ideal ventilation, and, where possible, an approximation to such a condition should be aimed at along with thorough self-cleansing and adequate flushing.

Flushing.—This is required to sweep away deposit and the slime which gathers on the walls between high and low water marks. To be effectual, a flush must run full-bore, and be sudden in action. Iron pipes stand flushing much better than brick culverts or stoneware tubes. Sewers may be flushed with the sewage itself, with slop waters, or with clean water, either rain or the ordinary supply. The last is undoubtedly the best process, as otherwise some fouling is always left on the walls. The lower part of a sewer should first be flushed, then the higher sewers and branch drains.

Methods.—These may be (A) non-automatic, or (B) automatic.

A. (1) A flap may be fixed on the outfall, and the sewage occasionally dammed back in a man-hole or special chamber. When released by the man in charge, it races to the outfall, scouring the sewer on its way. To obviate the danger of inattention, the flap or gate may be made so as to block only one-half or three-fourths the outfall. Thus there is always means of escape for the sewage.

(2) Sluice valves may be fixed in the man-holes themselves for the same purpose.

(3) Movable tanks of fresh water may be emptied down the sewer, or water discharged into them by hose from the street hydrants. Additional force may be obtained by using a pumping engine attached to the hydrant, and forcing the water through a perforated cylinder which is passed along the sewer from man-hole to man-hole.

B. (1) A tide-valve with a ball-cock attached, which floats on the rising sewage, and opens the valve with which it is connected by a chain.

(2) Pivoted gates, so balanced and weighted that a certain pressure of sewage behind them causes them to swing into a horizontal position and permit the on-rush of the sewer contents.

(3) Flushing tanks adapted to discharge by syphon action, and placed at the head of sewers or in man-holes. These are of various kinds, such as Field's and Adam's already described, or the special form of syphon devised by Miller.

(4) Automatic tippers of glazed earthenware situated in man-holes.

Outfalls.—The nature of the outfall depends on the nature of disposal of the sewage. Thus, if it is passed into the sea, lakes, or large rivers, iron pipes with their exits protected by valves are employed, reaching out a considerable distance from the shore or bank. The flaps or valves must be self-acting, and their hinges are best made of incorrodible gun-metal. In the case of the sea, the sewers may discharge into tanks which retain the sewage while the tide is rising, and from which it is set free during ebb tide. In the case of the estuary of a tidal river, the outfall must open below the town, and in the direction of the falling tide. In the case of sewage farms, the sewers end in tanks where their contents can be treated, and from which they can be discharged as desired. All outfalls must be ventilated.

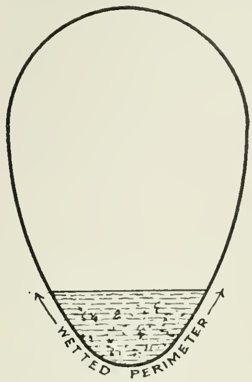


Fig. 167.

Velocity and Discharge considered in Sewers of Gravitation.—The velocity in a sewer should never be less than 2 ft. per second, and should not exceed 4 ft. per second. A higher speed is very destructive to inverts, on which there is a grinding action due to sand, gravel, and débris.

To calculate the discharge at any point, the velocity of the sewage flow and the sectional area of the current must be known, and multiplied together. $D = VA$. The velocity is estimated from the following formulæ :— $V = 55 \times \sqrt{2\ HF}$, where V = velocity in linear ft. per minute, 55 = a co-efficient of efflux, H = the hydraulic mean depth in feet, and F = the fall in feet per mile. As an alternative, one may take $V = C\sqrt{m} \times \sin\theta$, where V = velocity in feet per second, C = a coefficient of efflux, in this case 92, m = the hydraulic mean depth, θ = the angle of inclination of the sewer, $\sin\theta$ = a fall of 1 ft. in so many feet.

The hydraulic mean depth, as will be remembered, is the sectional area of the current divided by the wetted perimeter or part of the circumference wetted by the liquid (Fig. 167). In circular pipes the hydraulic mean depth is one-fourth the diameter of the pipe if running full or half-full. In egg-shaped sewers it varies according as the pipe is running full-bore, two-thirds full, or one-third full. In these cases it is the transverse diameter multiplied by ·2897, ·3157, and ·2066 respectively.

Full Bore.	Two-thirds Bore.	One-third Bore.
Trans. diam. × ·2897	Trans. diam. × ·3157	Trans. diam. × ·2066

The maximum velocity is thus seen to be obtained when the sewer is running two-thirds full, as the larger the hydraulic mean depth, the greater the velocity.

F is obtained by measuring the fall for a short distance, and then calculating it for the longer distance of a mile.

The sectional area in square feet of the part of the sewer filled by the stream may be obtained by multiplying the square of the diameter of the sewer by a fraction. In circular sewers running $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and full-bore, this fraction is respectively ·153, ·392, ·632, and ·785. It differs for oval sewers, the square of the height being multiplied by the fraction. For $\frac{1}{3}$ it is ·130, for $\frac{2}{3}$ ·338, for full-bore ·510. Finally, the velocity in linear feet per minute multiplied by the sectional area of the fluid in square feet gives the discharge of the sewer in cubic feet per minute.

Example.—A circular sewer having a diameter of 2 ft. and a fall of 1 in 586·7, is running half-bore. Find (*a*) the velocity of the sewage in feet per second, (*b*) the discharge from the sewer in gallons per minute.

(*a*)
$$\begin{aligned} V &= 55 \times \sqrt{2\ HF.} \\ &= 55 \times \sqrt{2 \times (\tfrac{1}{4} \times 2) \times \frac{5280}{586{\cdot}7}}. \\ &= 55 \times \sqrt{2 \times \tfrac{1}{2} \times 9}. \\ &= 55 \times \sqrt{9}. \\ &= 55 \times 3. \\ &= 165 \text{ ft. per minute.} \\ &= 2{\cdot}75 \text{ ft. per second.} \end{aligned}$$

(*b*)
$$\begin{aligned} D &= VA. \\ &= 165 \times (2 \times 2 \times {\cdot}392). \\ &= 165 \times 1{\cdot}568. \\ &= 258{\cdot}72 \text{ cubic ft. per minute.} \\ &= 258{\cdot}72 \times 6{\cdot}25. \\ &= 1617 \text{ gallons per minute.} \end{aligned}$$

NON-GRAVITATION REMOVAL OF SEWAGE.—*Shone's system* is a shoving or propulsion process applicable to places where sewage requires to be lifted from a higher to a lower level. This is done by aid of compressed air. The pneumatic ejectors are placed at several stations along the sewage system, are worked by compressed air from a central depôt, and propel the sewage along branch sewers to the main sewer and outfall. The sewage gravitates into the ejector chamber, which is deeply placed in the ground, and on rising lifts a bell and opens a valve which admits compressed air. The air thus admitted forces the sewage out of the chamber and up a pipe leading to a high-level sewer or outfall, while, at the same time, backward flow of sewage into the inlet or to the ejector chamber is prevented by a valve, and the further entry of compressed air is shut off. The system works automatically, flushes the sewers, and the ejectors sever the house drains from the main sewers. It is in use at Warrington, Eastbourne, Southampton, the Houses of Parliament, Cape Town, Rangoon, etc., and is very satisfactory.

Ordinary pumps may be used for the above purpose, and also in level ground, where a fall cannot be got, to propel the sewage to the outfalls, which in such cases frequently end in sewage farms.

Automatic sewage lifts requiring no machinery or attendants are also useful aids. They depend on syphon principles, sewage running at high levels being utilised to raise the low-level sewage.

The Liernur system is a "lugging" or suction process applicable to hilly as well as flat towns. It depends on the exhaustion of air and the action of a vacuum dragging excreta and slop waters to a central pumping station, storm and rain waters being excluded. Small iron pipes are used which resist pressure well. The system is in vogue at Amsterdam, Leyden, Riga, St. Petersburg, etc., and has recently been improved. It draws air down the soil pipes, but does not unseal the water-closet traps. The vacuum used is half an atmosphere, and the suction power is exerted on the sewers and house drains.

Separate and Combined Systems.—These have already been defined, but now require a more detailed consideration and comparison.

1. *Combined system.*—In this method, sewage and slop waters, trade effluents and subsoil waters, rain and surface waters, are all conveyed in the same sewer. Trade effluents reach sewers by means of drains similar to those used for sewage, but the materials used must be such as not to be acted upon by the effluent.

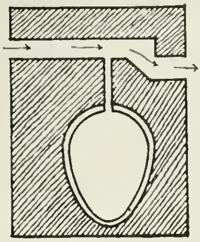


Fig. 168. — Bateman's intercepting weir.

Subsoil waters are collected in small drain pipes which unite and open into the sewer at a lower level.

Rain and surface waters gain access to the sewers from roofs and streets. Those coming from roofs have been considered. Streets should have a slope towards side gutters of from 1 in 20 to 1 in 40, and the gutters themselves should have a fall of 1 in 80 and lead to grated openings, silt trays being placed under the hinged gratings. These openings or catch-pits lead to underground, trapped drains passing to the sewers. The traps in these drains are apt to become unsealed in dry weather, and ought to be artificially renewed. In any system of sewerage intended to convey rain-water, provision must be made for dealing with the largest amount of rainfall known to have occurred in the district in the shortest time. All this rain does not, however, necessarily pass into the sewers. Some of course evaporates, some is absorbed by vegetation and soil, and some passes off by storm overflows. These are best made in the form of intercepting weirs, which in time of flood direct some of the rain to the nearest stream and only allow a certain proportion to enter the sewer. Bateman's is a good example (Fig. 168).

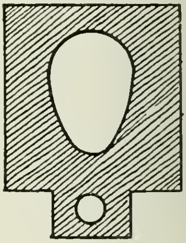


Fig. 169.

2. *Combined system minus subsoil water.*—In this case the subsoil water may be conveyed in special loosely-laid agricultural pipes, or may merely be permitted to trickle down through the loose earth at the sides of the sewer. On the other hand, it may be given a passage in special channels constructed in the base of the sewer invert, or in little pits fashioned under the base of the invert, and filled with gravel and loose stones (Figs. 169 and 170).

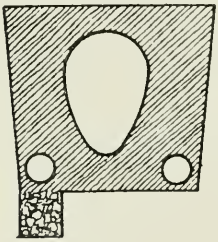


Fig. 170.

3. *Separate system.*—In this system, three sets of pipes are required, carrying respectively sewage and trade effluent, surface and rain water, and subsoil water. The rain surface waters are discharged into the nearest watercourse, lake, or into the sea.

4. *Partially separate system.*—In this instance, part of the rain and surface waters is admitted and part excluded.

Advantages of the combined system.—(*a*) The original cost is less, only one set of sewers being required; (*b*) the rain serves to flush the sewers; (*c*) it increases the volume of the effluent without diminishing its manurial value.

Disadvantages of the combined system. — (*a*) The increased volume necessitates greater expense if pumping is necessary; (*b*) more traps are required, and more outlets for sewer gas.

Advantages of the separate system.—(*a*) The sewage is more uniform, and, if used as manure, can be dealt with more readily; (*b*) the daily output is more easily gauged; (*c*) small pipes are required, and these foul less readily; (*d*) there is economy in construction and management; (*e*) watercourses are not deprived of part of their tribute; (*f*) pumping, if necessary, is less expensive; (*g*) fewer traps are required, and there is no chance for the escape of sewer gas from surface-water gratings.

Disadvantages of the separate system.—(*a*) The original cost is heavy; (*b*) there is no natural flushing by rain; (*c*) the multiplication of house drains may cause errors in connecting up the pipes to their appropriate systems; (*d*) rain surface-waters may be so foul as to be unfit for discharge into a watercourse; (*e*) slops may be, and frequently are, thrown down surface-water gratings.

DISPOSAL OF SEWAGE.

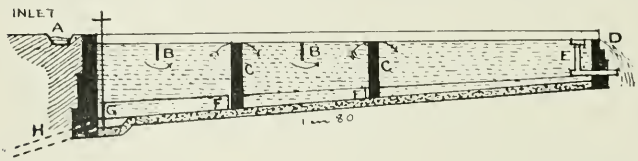
1. *Discharge into the Sea or a Tidal Estuary.*—The discharge of crude town sewage into rivers or streams is forbidden by law, and rightly so, as not only does it contaminate the water, but it may kill fish, create a general nuisance, and cause a silting up of the bed of the stream. Crude sewage, however, may be discharged into the sea, and where possible, the method is good on account of its cheapness and efficiency if properly managed. Its principal disadvantage is the fact that the manurial value of the sewage is lost to the land, though possibly what is lost to land is gained by fishes. It should not be employed by any town whose sewage cannot reach the outfalls within six hours. Many points require careful consideration, such as the shape of the coast-line, the nature of the tides, the prevailing winds and sea currents, both surface and deep, and the character of the foreshore. The sewage is sometimes apt to be washed back to the land, retained in pools amongst rocks, and constitute a nuisance and, it may be, a danger. To avoid this, it should only be discharged at the beginning of ebb-tide, and should be carried well out to sea in iron pipes beyond the low-water mark of the farthest out-going tides. Sea-water delays the oxidation of organic matter, but tends to cause a precipitation which fouls the sea-bottom in the vicinity of outfalls, though this is to some extent mitigated by the scouring action of tides. It is this action which makes discharge into tidal estuaries an offensive method, as the foul deposit is stirred up by the ever-advancing and receding water, and may be carried by it above the place where the outfalls are situated, and even above the town from which the sewage comes. An arm of the sea or tidal estuary may, within certain limits, be defined by the Local Government Board as a stream, and the discharge of crude sewage into it be thereby prevented. There is no objection to the discharge into the sea or tidal river of the purified effluent of sewage treated by land filtration, one of the methods to be considered.

2. *Subsidence and Precipitation.*—This includes the chemical treatment of sewage, and consists in the formation of a solid residue and a clarified effluent. The solid residue is obtained by permitting a simple settling or sedimentation of the sewage in tanks (see Fig. 171). This may be further assisted by the addition of chemicals, such as lime alone, or lime with sulphate of alumina, clay, calcic phosphate, magnesic chloride and tar, protosulphate

of iron, black ash waste, and herring brine. Alum, blood, clay, charcoal, and zinc sulphate (A.B.C. process) may be used, or permanganate of soda and sulphuric acid (Dibdin), or zinc chloride and sulphuric acid. Carbon or peat may be utilised. So may alum and iron (Spence's alumino-ferric with lime), as at Chiswick. Sulphate of iron is employed. In the Clarine process, oxychloride or muriate of iron are the precipitants. Peroxide of chlorine, ferrozone, thamisin, and oxynite, which contains manganese compounds or nascent oxygen, are other agents.

In dealing with sewage on a large scale, the precipitant must be readily obtained at small cost, and act rapidly and efficiently. To obtain the best result, a definite quantity must be added, the exact amount required being determined for each class of sewage, as an excess of precipitant wastes money and spoils the process. The most valuable precipitant is that which produces the least sludge with the most sewage, which is not injurious to those working with it, will cause no ill effects in the final disposal of sludge or effluent, and which does not leave an alkaline or coloured effluent or a sludge retentive of moisture.

If the effluent contain phosphoric acid, fungus growth is favoured. The effluent may be discharged into a tidal estuary, river, or stream, or may be filtered through special filtrants or applied to the soil, while the sludge may



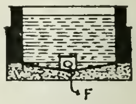


FIG. 171.—Settling tank for sewage. *a*, Inlet. *b*, Scum boards. *c*, Cross walls. *d*, Liquid overflow. *e*, Exit pipe. *f*, Sludge doors. *g*, Valve. *h*, Sludge removal pipe.

Section (transverse).

be made into cement, as in Scott's process, dug into the soil, manufactured by filter presses into manurial cakes, the moisture having been expressed, or taken out to sea and there deposited. Further, the sludge may be dried and concentrated by evaporation, a process only suitable in hot countries, or it may be burned in a refuse destructor. Precipitation removes practically all the suspended, but only a proportion of the dissolved organic matter, most of the fertilising agent remaining in the effluent. Precipitation is most effectual when the sewage is fresh, and when the precipitant is added hot and thoroughly mingled with the sewage by powerful mixing machines. The tanks (Fig. 171) should be 4 ft. deep, and may advantageously be arranged in series, and the sedimentation should take about one hour to be complete. The sewage enters in a shallow stream, falling over a weir the same breadth as the tank, the latter is divided up by partition walls over which the sewage also passes, and between which the sludge is deposited. The effluent passes off over a weir, while the sludge gravitates to a sludge-well, or is pumped out of the tank. The Dortmund tank is a deep, circular tank with a cone-shaped bottom. The sewage enters by a pipe at a point two-thirds down the tank, and is gently distributed by means of branching arms. The outflow pipe is at a higher level, to which the clarified effluent rises. The sludge is pumped out from the bottom.

(1) *The lime process.*—This consists in the addition of slaked lime, in the form of a cream, to the sewage in the proportion of 12 or 15 grs. to the gallon, and not more than 1 ton per 1,000,000 gallons. Sometimes a small quantity of chloride of lime is added, with the object of preventing fungus growth. The resulting effluent is unfortunately alkaline, so that it readily decomposes and is inimical to fish-life. The method is in use at Birmingham and elsewhere.

(2) *Lime and sulphate of alumina.*—The sewage having been mixed with lime, in quantities varying with the strength and composition of the sewage, a solution of crude sulphate of alumina is added, and a bulky precipitate of hydrate of alumina is obtained. Glasgow sewage works employ this process.

(3) *Lime and clay* (Scott's process).—The clay is used to enable the sludge to be made into a cement. Two tons of this has been produced from 1,000,000 gallons of sewage and $1\frac{1}{4}$ tons clay.

(4) *Lime and protosulphate of iron.*—This process acts mainly on the suspended matter, and as any excess of lime tends to dissolve a part of this, the quantity used is limited to 3 to 4 grs. per gallon, with 1 gr. of sulphate of iron per gallon. The effluent may have an offensive odour and require further treatment. The method is in use in London.

(5) *Lime and black ash waste*, the latter being derived from alkali and soap works, may be used. This refuse contains calcic sulphide which becomes changed into calcic sulphite and hyposulphite. The process is in vogue at Aldershot and in the Vale of Leven.

(6) *Lime and herring brine* (Amine's process).—A large quantity of lime, 20 to 50 grs. per gallon, and a small amount of herring brine, 3 to 4 grs. per gallon, which acts by virtue of the antiseptic trimethylamine it contains, are added to the sewage. The effluent remains clear, and does not undergo secondary decomposition. This is the method followed at Salford.

(7) *The A.B.C. process.*— The blood is now omitted, as it was found that the other ingredients acted equally well without it. The effluent is pure, and the sludge forms a good manure (native guano). The zinc sulphate is derived from the refuse from prussiate works, and the proportions used are 1 part sulphate of zinc, 5 parts quicklime, and 21 parts each of sulphate of aluminum and charcoal. About 167 grs. of this mixture per gallon of sewage are employed. The works at Aylesbury and Kingston-on-Thames are conducted on this principle.

(8) *Sulphate of iron* (Conder's process).—Here the precipitant is added at the head of the sewer or house drain and in the man-holes. Water which enters the drains or sewers flows through a ferrometer containing crystals of sulphate of iron and a fresh slice of lemon to add a vegetable acid. It requires constant attention, but is good on a small scale, as at Chichester barracks.

(9) *Peroxide of chlorine* (Howatson's process), obtained by the action of sulphuric acid on potassium chlorate, is in use on the Continent.

(10) *Ferrozone* is magnetic ferrous carbon, and is employed in the international process, which is a double method, combining the precipitation by ferrozone, 2 or 3 grs. to the gallon, with filtration of the effluent through a similar substance, polarite, a magnetic spongy carbon. The chief ingredient of ferrozone is ferrous sulphate, of polarite, magnetic oxide of iron. Example seen at Swinton.

(11) *Thamisin* (Reeve's process).—This patent substance is both a precipitant and deodorant, and is employed at Henley.

(12) *Oxynite.*—The manganese compounds form a close, firm sludge, and a good clear effluent results. The process is performed in three sets of deep circular tanks; the first for sedimentation, the second for precipitation, and the third for oxygenation. The chemicals can be recovered to some extent from the sludge, but if this is not done, the manganese compounds add to its manurial value, and the sludge does not decompose. A little of the sludge from the second tank added to that of the first will prevent its putrefaction. The oxygenation is carried on by the agency of micro-organisms with the aid of nitrate of soda added as a source of oxygen. The method is very good for sewage containing much trade effluent, and it may be applied to single factories.

(13) *The Hermite or nascent oxygen process.*—The oxygen is obtained by passing an electric current through sea-water or a solution of magnesium and sodium chloride between platinum and zinc electrodes. Like Conder's process, the resulting liquid is applied directly to the drains or sewers, but much electrolysed sea-water is soon reduced in strength by contact with paper, soap, and domestic waste waters.

3. *Evaporation.*—This process of disposal is associated with Liernur's system, when water is largely excluded and the quantity to be dealt with is small. The sewage is boiled and evaporated, and a good manurial powder obtained.

4. *Electrolysis* (Webster's process).—The sewage is allowed to flow through channels having iron plates set in them longitudinally. Alternate plates are connected respectively with the positive and negative terminals of a dynamo. The electric current splits up the chlorides and water of the sewage, chlorine and oxygen being given off at the positive pole, and combining with the iron. The chloride of iron thus formed in its turn combines with the carbonates of the sewage, and ferrous carbonates and oxides result. Hydrated ferrous oxide is the chief active agent, acting mechanically as a precipitant, and chemically, by coagulating albumin. It is also a deodoriser, and the effluent is not liable to secondary decomposition. There is an extensive oxidation of the suspended and dissolved organic matter, due to the oxides of chlorine and the nascent oxygen evolved. The bulk of the sludge is very much reduced, and the effluent may require sand filtration to remove iron. Electrical action may be continued in electric filters made of layers of coke forming positive and negative electrodes, and separated by sand or perforated tiles. Micro-organisms have been shown to be much reduced by electrolysis, which is employed at Crossness.

Sludge usually contains a large amount of moisture, and requires to be dried or pressed before being utilised. In this process it loses weight, and the decreased weight may be estimated by Robinson's formula: $W = \frac{s \times 100}{100 - p}$, where W = the weight of dried sludge, s = weight of solid matter in original sludge, and p = weight of moisture left in dried sludge.

5. *Filtration.*—Filtration through polarite has been considered, and if used alone, the filter beds should be covered with sand, as at Huddersfield. Filtration through carbon, ashes, etc., are not methods to be recommended. There remains the important question of filtration through soil. It is known as *intermittent downward filtration*, the intermittence of application being, as a rule, of primary importance, and is defined as "the concentration of sewage at

short intervals on an area of specially chosen porous ground as small as will absorb and cleanse it, not excluding vegetation, but making the produce of secondary importance." Soil acts on sewage—(1) Mechanically, freeing it from suspended matters. (2) By nitrification, which is an oxidation process due to nitrifying organisms in the upper layers of the soil and to the contained air, hence the necessity for intermittent application, which, however, can be dispensed with if the air can be artificially supplied by constant pumping through a perforated pipe into the middle of the filter beds. This method, however, finds its chief application in artificial filter beds of sand and broken stone. Two varieties of organism are believed to be concerned in the nitrifying process, one converting ammonia into nitrites, the other changing the nitrites into nitrates. The organic matters of the sewage are converted into nitrites, nitrates, and carbonates. Lime, soda, or potash must be present, with which the nitric acid can combine. (3) By aeration, the air contained in the soil interstices oxidising the organic matter. (4) By chemical interchange depending on vegetable growth. The best soil for the purpose is porous and loamy, or a loose marl with hydrated ferrous oxide and alumina. If the soil be clayey, it must be well broken up, and mixed with ashes. Sand and chalk are not suitable. In all cases there must be effluent drains placed at a depth of 6 ft., and if the ground be situated in the bend of a river, so much the better. The effluent drains should be 10 to 30 ft. apart; and if air be not supplied to the soil, the surface must be divided into four parts, so that one part is subjected to the sewage for six hours, the remaining three parts having meanwhile an eighteen hours' rest out of the twenty-four. The land should have a natural slope, so that the sewage can be distributed by gravitation, and the effluent drains act well. Various vegetables, such as cabbages, can be grown on ridges of the soil, between which the sewage runs in furrows, its flow being regulated by sluices, and distribution secured by branching trenches. The furrows are 1 ft. 9 in. to 2 ft. in depth, and sewage is allowed to lie in them to a depth of 1 ft. The breadth of the intervening ridges is 2 to 4 ft. One acre of ground will suffice to deal with the crude sewage of 2000 people, and of 5000, if the sewage be clarified. The furrows should not be placed directly over the under drains, and are occasionally altered in position after the ground has been ploughed and dug over. The effluent contains nitrates and nitrites and chlorine unchanged. The method, which is preferable to irrigation as a means of dealing with a sewage largely composed of trade effluents, is employed at Hitchin, Kendal, Merthyr-Tydvil, and Croydon.

6. *Irrigation.*—Broad irrigation is defined as "the distribution of sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied." The land chosen should be such that the sewage can gravitate on to it, and almost any variety of soil is suitable if well and properly drained. Friable loam, consisting of clay, sand, and some vegetable loam, is however the best. Chalk must be looked on with suspicion, as it may contain cracks and swallow-holes admitting sewage to water-supplies. In all cases the geology of the part must be known, as porous strata may carry the sewage long distances, and danger may thus arise. The land must be levelled, and, unless very permeable, must be underdrained by porous earthenware pipes, laid 6 ft. deep and from 20 to 100 ft. apart, conveying the effluent to the nearest watercourse. A clay soil requires to be well broken up and especially well drained.

If this is done, owing to the mineral matters it contains, it will produce a better crop than a light sandy soil, rank growth being retarded. The sewage, which must be fresh, may be applied in one of three ways—

(*a*) *Contour method.*—The sewage runs in channels cut along the contour lines of the ground, and with sufficient slope to maintain a current. By means of a stop-shutter the current is dammed back, and the sewage overflows the inclined surface. It is only suitable for steep ground.

(*b*) *Pane and gutter method.*—Here the channels do not follow the contours, and may be made of tiles or concrete, though they are usually merely shallow trenches. The term pane is applied to the part between two gutters.

(*c*) *Ridge and furrow system.*—The ridges are from 30 to 60 ft. broad, and the concrete, brick, or stoneware carriers run along the top of them, and are fitted with sluice valves. The main carriers should be from 6 to 10 in. deep, 1 to 4 ft. wide, and have a fall of 1 in 500, or 1 in 600. There is a furrow between each two ridges, into which the sewage flows when dammed back in the carrier. The furrows have a longitudinal fall in the direction of the general outflow, and this method is suited for heavy and flat land. The best sewage farm crops are Italian rye-grass, mangold wurzel roots, cabbages, tares, and clover, and if there is not too great a volume of sewage, cereals can be grown.

Osiers and aquatic plants can be utilised for the purification of the sewage, while the growing of peppermint is a profitable industry.

Stock-rearing and dairy-farming also go far to make such an enterprise pay, and no danger results. One acre is usually required for every 100 people, and the process can go on in very severe frost owing to the high sewage temperature. Supplementary filter beds are useful to prevent overflooding of the farm, and it is well to remember that 100 tons of average sewage covers 1 acre 1 in. deep. The process is in vogue at Craigentinny in Edinburgh, at Leamington, Blackburn, Cambridge, etc., but land is often very expensive, and it is difficult to properly control and work a large sewage farm.

In both land systems it is well to employ settling tanks previous to the sewage being applied to the soil. They may work on the intermittent or continuous plan ; the latter being best, as too great a subsidence is not wanted, but merely a removal of grosser and adventitious substances. Such a tank has a bottom sloping towards the inlet, and the sewage having entered it has to pass under scum boards and over cross walls, the sludge falling to the foot, and gravitating to an outlet at the lower end of the slope.

Area of land required for sewage disposal (*Whyatt*).

1. Irrigation without precipitation.	Stiff clay . .	1 acre for	25 people.
	Loamy gravel .	1 ,,	100 people.
2. Intermittent filtration without precipitation.	Sandy gravel .	1 ,,	100 to 300 people.
3. Irrigation with precipitation .	Clay . . .	1 ,,	200 people.
	Loamy gravel .	1 ,,	400 people.
4. Intermittent filtration with precipitation.	Sandy gravel .	1 ,,	500 to 600 people.
5. Precipitation and filtration, through filters of coal, polarite, coke-breeze, burnt ballast, etc.	. . . . .	1 ,,	2000 people.

7. *Bacteriolysis* is the process whereby the disintegrating power of micro-organisms upon organic matter is utilised to break up sewage, and render it innocuous, at the same time preserving to some extent its commercial value. Engineers and sanitarians are becoming more and more convinced that this, in some form or other, is the method of the future for dealing with one of the most difficult problems of the day. The method is carried out either in filter beds or in tanks. The walls of the beds may be of earth alone, clay being good, or of earth along with bricks. The organisms may be either entirely aerobic or a combination of aerobes and anaerobes. The sewage, which should not be very acid, when treated in bacterial filter beds is first screened of its grosser impurities and adventitious substances. This is effected by subsidence in a detritus chamber, or by an automatic rotatory screen driven by the flowing sewage itself. A flume may be used instead of the screen; it is of the nature of a box with transverse partitions which slopes towards the bed. Sewage then passes to the bed, and is distributed over it by automatic feeders arranged on a syphon principle, or by an automatic sprinkler. The bed is composed of various materials, of which pan breeze covered by a layer of sand is perhaps the best. Pan breeze is coke from gasworks, which has been several times heated in a pan to a white heat. Other materials used are clinker, burnt ballast, broken granite, slate, sand, gravel, coal, and polarite, covered like the pan breeze with a layer of sand. The coke should be in pieces each about the size of a walnut. The bed varies in depth from 3½ to 13 ft., and the bacterial action takes place in the interstices of the filtrant, the surface of the coke becoming covered with an adherent slime swarming with organisms. Until the slime is formed a bacterial bed does not act as an efficient filter. Thus the filter bed takes about four weeks to mature. The action is intermittent, as aeration is essential, and any one bed is only allowed to be sewage-saturated for six hours out of the twenty-four. Artificial aeration may be provided by forcing air, conveyed in a pipe, to the bottom of the filter bed, through which it ascends and escapes by surface vents. As the sewage trickles down it passes the ascending air in the interstices. The bed is kept full of sewage for two or three hours. A stratum of sharp sand is placed at the bottom of the bed to prevent the first part of the effluent being foul from deposit. The bed should have an absolute rest of one week in six. Frost is non-preventive to the action. The main object of such a bed is to reduce sludge to a minimum, while the cost of the method is even less than that of precipitation or irrigation. The effluent is collected by loose-jointed stoneware pipes in the floor of the filter bed, and is run off from the bottom of the bed. If not sufficiently pure, it may be passed through a second filter, or applied to land before it is run into the nearest watercourse.

The chemical changes produced by the organisms are—

1. The conversion of nitrogenous organic matter, such as urea, into ammonia, carbonic acid and water, and of non-nitrogenous compounds into carbonic acid and water.

2. The decomposition of cellulose, which is known to be effected by the *B. butyricus*, the *B. gummis*, and *B. putredinis*, etc. Marsh gas is one of the products of this action.

3. The oxidation of ammonia into nitrites, and of nitrites into nitrates. This is accomplished by nitrifying organisms, such as are found in the upper layers of the soil and in the sewage itself.

4. The reduction of the nitrates into nitrites, with separation of oxygen, which oxidises organic matter and re-forms nitrates. This action is due to denitrifying organisms.

The filter bed cannot render the effluent bacteriologically pure, but a reduction of 99 per cent. in the number of aerobic bacteria can be obtained.

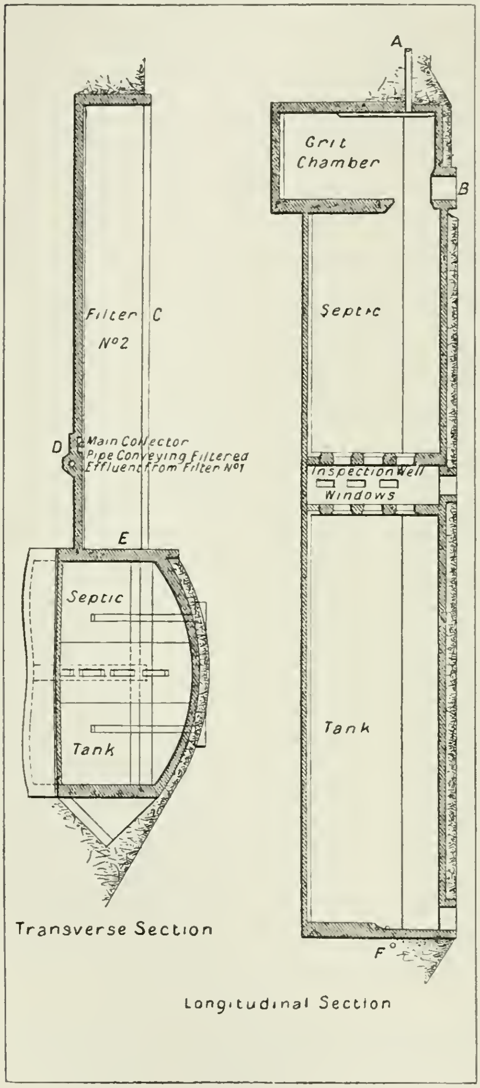


Fig. 172.

Addenda. — If sand and gravel be used, it is better to filter with the outflow open, but at the same time intermittently. Lowcock's bacteriological filter consists of sand and gravel, and is fitted with air pipes. Garfield's is a coal filter, the coal being well washed, and the bed 4 or 5 ft. deep. The thermal aerobic filter of Whittaker and Bryant provides (*a*) for the liquefaction of sewage, and (*b*) for aerobic filtration at a raised temperature, which is achieved by blowing a jet of steam into the sewage as it is sprinkled on to the filter. The heat serves to aerate the filter from below upwards. There are a large variety of other methods whereby similar processes can be carried out, either by filtration alone (Ducat), or filtration combined with preliminary retention in open tanks to permit of liquefaction of the sewage by bacterial action (Dibdin). The Scott-Moncrieff filter bed acts by an upward filtration, and is specially adapted for dealing with the sewage from large single residences and institutions. The sewage enters at the bottom of an open tank containing large stones, and passes slowly upwards through them. During its passage the solid organic matter is liquefied and dissolved. From the top of the tank the effluent, now free from suspended organic matter, passes along a series of channels containing stones, in which it undergoes further aeration. It then dribbles downwards through trays filled with coke, and thus undergoes nitrification.

In all these processes the Local Government Board require that not more than "two volumes of storm water plus the normal sewage be treated as sewage proper, whilst an additional three volumes must receive special treatment, either by a filter used for that purpose only, or by an area of land also put to no other use. If a special storm filter is provided, it should be of sufficient extent to allow a rate of filtration of 500 gallons per square yard per diem."

The Local Government Board will not sanction any scheme which does not provide for the passage of the effluent through land before its admission into a stream or river.

The Septic Tank or Anaerobic Process.—This necessitates the provision of an impermeable air-tight tank (Fig. 172), built of stone set in cement, and situated wholly underground, thus being excluded from light as well as air. It is really a perfected form of cesspool, the roof being formed of concrete, arched on brick piers, and covered with soil and turf. The sewage enters a detritus chamber first of all, and then the tank, the former being 3 ft. deeper than the latter, and provided with an overflow weir for excess of storm waters. From the chamber it enters the tank by two openings placed 5 ft. below the level of the surface of the tank sewage, and thus the scum in the tank is undisturbed; there is no backward escape of gas from the tank, and no air is carried into the tank. The effluent flows gently through a slot which runs the whole length of the distal wall, and is situated 15 in. below water-level, that is, between the surface scum and the slight deposit at the bottom. There is a brick inspection well with plate-glass windows placed in the centre of the tank, whence the interesting bacterial operations can be viewed *sans peur et sans odeur.* The tank or tanks must be large enough to contain the maximum day's sewage supply and the permitted proportion of storm waters. This ensures that the flow through the tank is not too rapid. The sewage must remain in the tank about twenty-four hours on an average. The tank, like the filter bed, requires a certain time to attain maturity, but once the process is started, the sewage continues to work out its own salvation, yet not without trembling, for there is a constant agitation going on in the tank, masses of sewage rising and falling owing to gas production and bubble-bursting. A gradual disintegration of all the solid particles takes place, a thick scum forms on the surface, the organic matter is in part dissolved and in part resolved into gases, and there is a very slight deposit of true sewage sludge, with sand, grit, etc., which even after years only attains a depth of a few feet, and can, if necessary, be removed by pumping. The supply of bacteria is inexhaustible. The gases produced, which fill the upper part of the tank, are hydrogen, marsh gas, sulphuretted hydrogen, carbonic acid, nitrogen, and carburetted hydrogen, and these may be in part employed as illuminants for the general works. The effluent on emerging from the slot is like ditch-water, and has a distinct but not diffusible odour. Its further history markedly differs from the anaerobic treatment accorded the sewage, for it passes to an aerator (Fig. 173), where it is brought into contact with air, and oxidised by being made to run over the sides of a weir as two thin sheets falling into troughs. Thereafter it is distributed on aerobic filter beds, composed preferably of $4\frac{1}{2}$ ft. of crushed furnace clinker resting on $\frac{1}{2}$ ft. of coarse gravel. Automatic alternating gear regulates the additions of the effluent, and secures an equable distribution, and the filtration must be intermittent. The effluent resulting from the filter beds is clear and sparkling, and, it is asserted, can be drunk, if desired, with impunity. It should, however, be run into the nearest *inanimate* watercourse, after having been passed through land, in accordance with the rules of the Local Government Board. For such an effluent ½ acre to every 1000 people suffices. The effluent does not undergo secondary decomposition. On leaving the anaerobic tank it is found to have lost both free and albuminoid ammonia, the former to a considerable, the latter to a slight extent, while there is also a diminution in oxidisable organic matter. On leaving the filter beds, a great decrease in albuminoid ammonia is apparent on examination, and ·1 per 100,000 may be taken as the limit to be permitted. Such is the process in use at Exeter, Yeovil, and Barrhead, and it seems to be specially applicable to small towns, institutions, hospitals, schools, barracks, etc., as it is comparatively cheap, produces no nuisance, and requires very little attention.

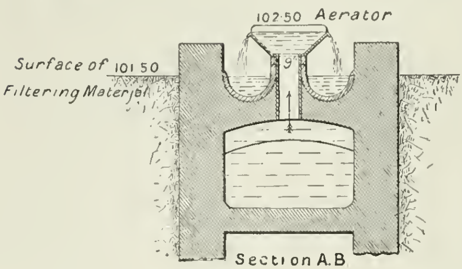


FIG. 173.

General remarks.—As regards sewage effluents generally, the Rivers Pollution Commission recommend that no effluent be admitted into a stream if it contain more than the following quantities :—

Constituents.	Limit.
1. Suspended matter { Dry organic . . .	1 part per 100,000 by weight.
Dry mineral . . .	3 parts per ,, ,,
2. Dissolved matter { Organic carbon . .	2 ,, ,, ,,
Organic nitrogen . .	·3 part per ,, ,,
3. Metals in solution, except arsenic, potassium, sodium, calcium, and magnesium . .	2 parts per ,, ,,
4. Metallic arsenic in solution, suspension, or chemical combination	·05 part per ,, ,,
5. Chlorine, as free chlorine	1 ,, ,, ,,
6. Sulphur present as H_2S or soluble sulphuret .	1 ,, ,, ,,
7. Acidity, as hydrochloric acid	2 parts in 1000 distilled water by weight.
8. Alkalinity, as caustic soda	1 part in 1000 distilled water by weight.
9. Oily matter, petroleum, or hydrocarbon oil .	·05 part per 100,000.

In addition, a colour disqualifies, which is distinct in a stratum of 1 in. depth, when examined in daylight in a white vessel.

Dr. Barwise recommends that an effluent should have the following constitution :—

Total suspended matter . . .	Less than	3	parts per 100,000.
Oxygen absorbed at 80° F. in four hours	,,	1·5	,, ,,
Albuminoid ammonia	,,	·15	,, ,,
Nitrogen as nitrates	,,	·25	,, ,,

However clear an effluent may be after leaving the precipitating tanks, it still contains soluble organic matter which may putrefy, and must be converted into harmless and inorganic substances if it is to be admitted into a stream or river. Unless absolutely pure, sewage effluents, like sewage itself, undergo oxidation when passed into rivers or streams. There is a disintegration of the organic matter by the water bacteria with the aid of oxygen dissolved in the water, or derived from nitrites and nitrates present in the effluent. Dr. Rideal has suggested that the ratio of the different forms of nitrogen present in an effluent may afford a guide to its character. The ratio of the chlorine to the total nitrogen in fresh excreta is taken as the standard.

Testing of Effluents.—See Sewage, p. 263.

The beneficial effects of the various bacteriological processes are undoubted, as shown by a comparison of the chemical composition of raw sewage compared with that of the effluent. Does the same hold good with regard to their bacteriological state? An absolute answer cannot as yet be given, since, owing to the difficulty of isolating pathogenetic microbes from an effluent, mere failure to find them does not disprove their presence. Houston, Clowes, and others have worked at this subject, and it has been shown that effluents contain *B. coli communis*, *B. enteritidis sporogenes*, liquefying organisms, streptococci, etc. There seems to be little difference in the character, though on the average some diminution in number, of the organisms in effluents as compared with raw sewage. Houston believes that if delicate streptococci, which are usually pathogenetic and often derived from the intestinal tracts of animals, can pass through filter beds and be present in effluents, it is extremely probable that the *B. typhosus* and *V. choleræ* can do likewise, even though there is no evidence to this effect.

The advantages of bacterial over chemical treatment have been thus summarised by Clowes—(1) It requires no chemicals; (2) it produces no offensive sludge, but only a deposit of sand or vegetable tissue, which is free from odour; (3) it removes the whole of the suspended matter instead of only about 80 per cent. thereof; (4) it effects the removal of 51·3 per cent. of the dissolved, oxidisable, and putrescible matter, as compared with the removal of only 17 per cent. effected by the present chemical treatment; (5) further, the resultant liquid is entirely free from objectionable smell, and does not become foul when it is kept; moreover, it maintains the life of fish.

RAILWAY TRAVELLING.

With the extension of the application of lavatory accommodation to trains, a new nuisance and danger has arisen, owing to the primitive method of disposal adopted. When used when the train is in motion, the evacuations are apt to foul the under surfaces of the succeeding carriages, and in any case drop on the permanent way, where they dry and form part of the dust raised by other trains. As sick people are frequent users, enteric fever may thus be disseminated. When used in stations, the condition of things is even worse. The remedy is not easy to suggest, but it would be better if the excreta were received into a water-tight tank, which could be discharged into proper receptacles at the end of the journey, having been exposed to the action of a germicide, such as carbolic acid, on the way.

Possibly the employment of a dry system, in which the collected excreta along with sawdust and fine ash might be used as fuel, may have a future before it.

COLLECTION OF REFUSE.

The collection of refuse rests with the local authorities, who may themselves superintend the business, or contract for it to be done. Different methods obtain in different towns. The custom of collecting house waste in ashpits still prevails in too many towns. The ashpits are not emptied with sufficient frequency, and a daily house-to-house collection, if properly conducted, is much to be preferred. The collecting carts should be covered, should go their rounds at a stated time in the morning, and the house waste should be put out for collection immediately prior to the coming of the cart, whose approach may be heralded by a bell. The habit of putting out ash-buckets the night before should be forbidden, starving dogs and diligent rag-pickers alone benefiting by this insanitary procedure. The receptacles should be of impervious material, preferably of galvanised iron, covered and daily cleansed. Streets should be scavenged daily, and no accumulation of shop and market waste permitted. A special charge is usually made by the local authority for collecting trade refuse. In the poorer parts of a town it is a good plan for the local authority to provide fixed receptacles for refuse, which are regularly emptied.

DISPOSAL OF REFUSE.

Refuse consists of all manner of domestic waste, such as ash-bin contents, road sweepings, and the débris from shops, markets, and streets. Kitchen waste should as far as possible be burned, especially that liable to decompose. It is best dried through the night, and acts as fuel in the morning. Dust-bins, which must be covered, should not be inside houses or built against house walls. Road sweepings should be directly removed in barrows or carts. Before disposal, the refuse may be sorted either by hand or machinery. Dust evolved should be drawn into furnace draughts, and so removed.

Methods of Disposal.—(1) By filling up waste ground, such as old quarries; (2) by tipping into the sea at a distance from the shore; (3) by employment as manure; (4) by destroying with fire in a destructor.

(1) This method not only causes a loss of material, but the land so covered or formed cannot be used for building purposes for at least three years. Moreover, the accumulation often causes a nuisance, as it is apt to putrefy.

(2) Here, again, there is loss of material; fishing grounds may be ruined, and fishermen's nets damaged, while the mere removal is a dirty and expensive business, and apt to be interfered with by weather.

(3) The conveyance of large quantities of such refuse by road, rail, or canal is expensive, and apt to be offensive, while storage on the farms is another source of nuisance, and the manure is not good. The refuse may be used for making artificial manure, in which case it is either washed, or washed and filtered, to effect a separation of grit, slop, and water. The slop is then utilised, the grit being used for building purposes, and the water passing to the sewer.

(4) This is the process coming more and more generally into use, and it has for its object an efficient and cleanly disposal, together with some reimbursement from the resulting clinker, which is now being made into a form of concrete for building purposes, and may be used to make roads, mortar, or as fuel. Further, the destructor heat may be utilised for ventilation, lighting, and disinfection in various ways.

Destructors are of two kinds—(*a*) the slow combustion furnace, which is used without a forced draught, and does not attain so high a temperature, or in the same time consume so much refuse, as (*b*) the high temperature or forced draught furnace. The essential parts of a destructor (Fig. 174) are a sorting

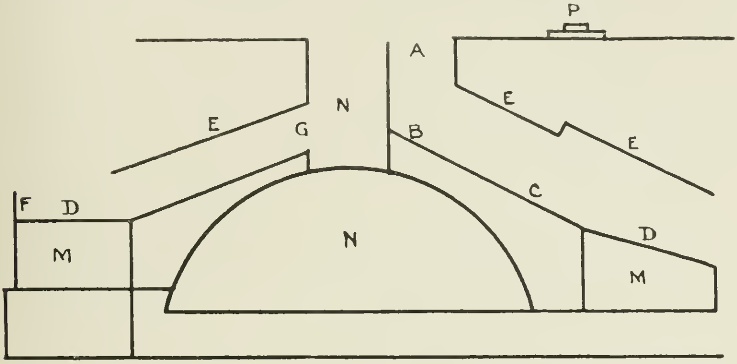


FIG. 174.—Refuse destructor. *a*, Opening for refuse. *b*, Inclined hearth. *c*, Drying floor. *d*, Fire bars. *e*, Reverberatory arch. *f*, Clinker door. *g*, Opening for gases. *m*, Ashpit. *n*, Main flue. *p*, Mattress opening.

floor, feed-hoppers, through which the refuse is pushed to inclined drying hearths, a cell or combustion chamber, an ashpit, and main flue ending in a tall chimney. Some forms have fume cremators (Fig. 175), which consist of a secondary furnace placed between the cells and the main shaft. It is designed to consume the fumes, and is fed with coke breeze. So placed, however, such fume cremators are apt to interfere with the draught, so that another method is to have special fire-brick arches in connection with the furnace cells. Through these the fumes pass to the shaft, being completely oxidised en route. In the second class the forced draught is obtained by means of fans or steam-jet blowers, and a temperature of 2000° F. secured. The chimney requires to be higher than for an ordinary coal or coke-fed furnace, as inferior fuel creates a poorer draught. The Horsfall destructor is an excellent type of the second variety ; and as an example of the first may be mentioned Fryer's, with Jones' fume cremator, where the wear and tear is less and the cost reduced. The Horsfall employs a very high temperature, and the fumes are subjected to the highest temperature of all. The furnace also has exceptional steam-raising power. About one-third of the fuel is obtained in the form of clinker, the remainder being consumed as fuel. One great disadvantage about destructors is the nuisance arising from dust, and in the Perfectus destructor an effort is made to avoid this by catching the fine black dust in pits connected with the

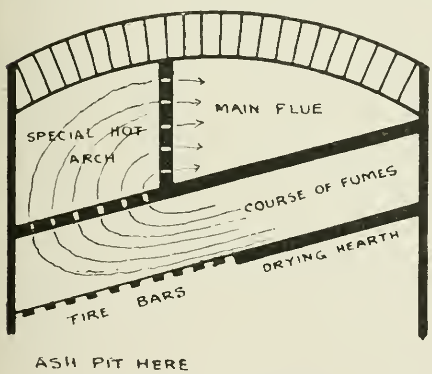


FIG. 175.—Fume cremator.

main flue. Baffle plates in the shaft have proved a failure. For small towns, Ball's destructor, by virtue of its cheapness and efficiency, is likely to meet a want.

The dust evolved from a destructor chimney has been analysed, and found to contain 93·6 per cent. of mineral matter, and 6·2 per cent. of organic matter.

VI. MEANS AND METHODS OF ASCERTAINING THE EFFICIENCY OF SANITARY APPLIANCES IN BUILDINGS, AND A CONSIDERATION OF THE DEFECTS WHICH MAY BE ENCOUNTERED.

Inspection of Individual Houses.—In Scotland, each division of a tenement in the individual occupation of a tenant is regarded as a separate house; while in England, all that is under the eaves forms a house. In drawing up a report on the sanitary condition of a house, the medical officer of health should note the following points:—

(1) The name and address of the owner. (2) The name of the occupier. (3) The exact location, number, and name of the dwelling, and the local authority in whose district it is situated. (4) The number of inhabitants, their sexes and ages, and the occupations they follow. (5) The arrangement of inmates as regards aggregation into families, and their distribution in sleeping apartments, and in the occupation of the basement. (6) The animals kept in and outside the house. (7) The site, its natural characteristics, such as geology, physiographical environment and dryness, and its artificial relations as regards preparation, surroundings, and drainage. (8) The construction from foundation to chimneys, with reference to structural stability, hygienic relations, and power of resisting fire; also the condition as regards repair. (9) The internal arrangement of lobbies, staircases, and rooms. (10) Ventilation and heating, natural and artificial, with calculations of cubic space per inmate of each room. (11) Water supply—source, quantity, quality, means of storage and distribution; relation to drainage and gas fittings. (12) Sewage disposal; method; application of method. (13) Waste-water disposal; method; application of method. (14) Refuse disposal; method; application of method. (15) General cleanliness.

Most of these points are determined by inquiry, inspection, and mensuration, but some can only be elucidated by the application of special tests.

Ventilation.—In this connection mensuration is required to find the cubic capacity of rooms, and the area of inlets and outlets.

Rooms.—(*a*) Of rectangular shape. The cubical capacity equals the length × breadth × height, c.c. $= l \times b \times h$.

(*b*) Rectangular, but with sloping ceiling, c.c. $= l \times b \times$ mean height. The mean height is obtained by adding the maximum and minimum heights, and dividing by 2.

(*c*) If the walls are all vertical and the ceiling not sloping, no matter what the shape of the room may be, its c.c. = the area of the floor × the height of the walls. The area of the floor may be found by dividing it up into various mathematical figures and adding their areas, which are obtained as follows:—

Triangle.—Base × height, and ÷ the product by 2.

Circle. — $D^2 \times \cdot 7854$ or $r^2 \times 3{\cdot}14159$. D = Diameter. r = Radius.

$$3{\cdot}14159 = \frac{22}{7} = \pi = \frac{\text{Circumference of circle}}{\text{Diameter of circle}} \cdot \quad \cdot 7854 = \tfrac{1}{4}\pi.$$

Ellipse.—Long D × short D × ·7854.

Regular polygon.—Divide into triangles.

Irregular polygon.—Divide into triangles.

Space with curved sides.—Divide into triangles and segments of a circle. Then the area of the circle segment $= \frac{H^3}{2C} + \frac{2}{3}HC$, where H = the height, and C = chord.

(*d*) The cubical contents of other mathematical shapes are obtained as follows:—

Cylinders.—Base × height, *i.e.* area of end × height.

Regular prisms.—Solid triangle. Area of section × depth.

Cones and pyramids.—Area of base × $\frac{1}{3}$ height.

Spheres.—$D^3 \times \cdot 5236$ or $\frac{D^3 \times \pi}{6}$.

Domes.—Area of circular base × $\frac{2}{3}$ height.

Irregular solids.—Divide into simple component figures, and add their cubical contents.

Circumference of circle $= C = 2\pi r = D \times 3{\cdot}14159$.

Diameter of circle $= \frac{C}{\pi} = \frac{C}{3{\cdot}14159}$.

Circumference of ellipse $\frac{l+s}{2} \times \pi$. l and s = long and short diameters respectively.

Having ascertained the cubic space, divide it by the number of inmates using the space, and so obtain the amount available per head. To find the average floor space for each occupant, divide the area of the floor by the number of inmates. The total floor space should be one-twelfth of the total cubic space. Deductions must be made for solid bodies in the room, such as projections, furniture, and human beings, while the cubic space of recesses has to be added. It is customary to allow 10 cubic ft. for bed and bedding; while the amount of cubic space which a man occupies can be obtained in cubic feet by dividing his weight in stones by 4. The area of an inlet or outlet is got by multiplying its length by its breadth. Linear measurements should be expressed in feet and decimals of a foot. Square inches can be converted to square feet by multiplying by ·007. Having measured the cubic space, it is necessary to determine—(1) the direction of air currents; (2) the rate of movement of air currents. The direction is ascertained by observation alone, or assisted by the smoke test, or the test with light floating bodies. Smoke is best generated from smouldering cotton velvet. A candle flame may be used for strong currents. The rate of movement is ascertained by an instrument called the anemometer or air meter, by a manometer, or, if the air is still and movement is only due to the difference in weight between internal and external columns of air, by Montgolfier's formula. Care should be taken that the house is under normal conditions when the test is applied.

The best anemometer is Casella's air meter (Fig. 176), which consists of revolving vanes like windmill arms attached to a registering dial. This is placed in an outlet, care being taken that it is not directly at the centre of the outlet, where the velocity is greater than the mean velocity, nor too close to any wall, where friction reduces the velocity to less than mean velocity. The best position is two-fifths of the diameter from the side of the opening. If used for a ventilating shaft, it should be placed well inside it. Several observations ought to be made, and the average of them taken. The times at which the vanes begin to move is noted, and after a certain period, say a minute, movement is stopped and the instrument removed, the dial having in the meantime registered the velocity in feet and decimals of a foot. Multiply the velocity per minute by the sectional area of the outlet, and the discharge is obtained in cubic feet per minute (D = VA). This multiplied by 60 gives the discharge per hour, and this divided by the number of inmates gives the discharge per head per hour. In the manometer the air current impinges on a water surface, and drives water up a tube, and from the height at which this water stands in the tube the velocity can be calculated. It is not so convenient for general use as the air meter. In calculating by Montgolfier's formula, the velocity is ascertained from the formula $v^2 = 2gh$, where v is the velocity in feet per second, g the acceleration due to gravity, and h = the difference in height between the height of the column of outer air above the inlet and the height to which the column of hotter air in the ventilating shaft would contract if it were reduced to the density of the outer air. Premising that the barometric pressure is equal in both the outer and inner columns, and therefore may be disregarded, and that air expands $\frac{1}{492}$ (·002) of its volume for every degree Fahrenheit through which its temperature is raised, let us suppose that we are dealing with a ventilating shaft 40 ft. high, and that the difference in temperature between the internal and external air is 25° F. Then the calculation is $v^2 = 2gh$ or $v = \sqrt{2gh}$; and since g is 32·2, $2g = 64·4$, and its square root is 8·08 or roughly 8, and the formula becomes $v = 8\sqrt{h}$. Then h = the column of air above the inlet corresponding to the height of the outlet ventilating shaft, *i.e.* 40 ft., minus the height to which the 40 ft. of hotter air would contract if reduced to the density of the outer air, *i.e.* $\frac{40}{1 + 25 \times ·002}$.

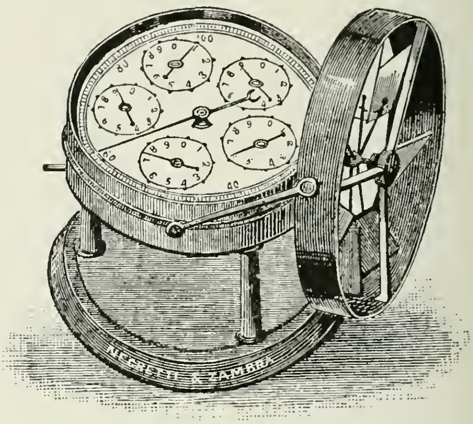


FIG. 176.—Casella's air meter.

Thus the formula now reads $v = 8\sqrt{40 - \frac{40}{1 + 25 \times ·002}}$.

This simplified gives $v = 8\sqrt{40 - 38}$.

$= 8\sqrt{2}$.

$= 8 \times 1·41$.

$= 11·28$ ft. per second.

This is a theoretical velocity, since no allowance has been made for friction. The actual velocity will be only one-half or three-fourths of the above. As before, if discharge is required, $D = VA$.

To find whether the size of inlets and outlets is sufficient to give a proper supply of fresh air per head per hour, De Chaumont's formula is employed, namely, $D = 200 \times \Phi \times \sqrt{\cdot 002 \times x \times (t - T)}$, where

D = the delivery of air in cubic feet per hour.

$$200 = \text{a constant} = \frac{3600\ (60 \times 60 \text{ seconds per hour})}{144\ (\text{square in. in a square ft.})} \times \sqrt{2g}.$$

Φ = The sectional area of inlet and outlet in square inches.

x = The height of the heated column of air in feet.

t and T = The internal and external temperature respectively.

Thus, if D be 3000, $x = 20$ ft., $t = 60°$ F., $T = 45°$ F., then

$$3000 = 200 \times \Phi \times \sqrt{\cdot 002 \times 20 \times (65 - 45)}.$$

$$\Phi = \frac{3000}{200 \times \sqrt{\cdot 002 \times 20 \times 20}}$$

$$\Phi = \frac{3000}{174}.$$

$$\Phi = 17 \cdot 2 \text{ square in.}$$

To counterbalance the effect of friction, this number must be raised by the addition to it of one-fourth of itself. It thus becomes 21·5.

In such testing of ventilation the influence of friction on air currents has to be borne in mind, and, if necessary, calculated. The conditions influencing friction in a ventilating shaft are as follows :—

1. *Length.*—In two shafts, otherwise equal in dimensions, the friction is greater in the longer shaft in direct proportion to its excess of length.

2. *Size of openings.*—For similar sections the friction is inversely as the diameter of the openings. The smaller the opening, the greater the friction. Where tubes of similar section have openings differing in shape, the friction is increased in the smaller openings in the ratio of the square roots of the areas of the openings.

3. *Shape of openings.*—Friction is least with a circular opening, since of any mathematical figure the circle has the largest area for the smallest periphery. With any other shape of opening the friction increases in proportion to its difference from a circle enclosing the same area.

4. *Changes of direction of shaft.*—Any bend in a ventilating shaft greatly increases the friction. This is proportional to the angle formed by the bend. Thus a right angle diminishes the velocity of the air current one-half. A shaft having two rectangular bends will thus have the total velocity of the air current in it reduced to one-quarter of what it originally was.

5. *Interference* with the lumen of the shaft, which may be blocked by dead birds, animals, dust, débris, etc., will cause a great increase in friction.

6. *The specific gravity of the air.*—Vitiated air has a slightly higher specific gravity than fresh air, and thus requires a greater current for its removal.

In order to complete the report on the ventilation, the condition of the air in the house under natural conditions must be ascertained. The examination of air is considered elsewhere (p. 160), but for purposes of convenience a brief résumé of those points having a special bearing on house testing is here given.

Any closeness or odour should be noted on immediate entry from the fresh air, and it is to be remembered that the greater the humidity of the air, the more perceptible will be the odour of organic matter if it is present. The reaction should be tested by moistened litmus or turmeric paper exposed to the air for some hours. The oxygen may be estimated by the nitric oxide method, or by means of pyrogallic acid. The carbonic acid must be determined not only for its own sake, but also because it is an index of the amount of organic matter present. This is done by Pettenkofer's process, or Angus Smith's method. The ammonia present may be computed by aspirating the air through dilute hydrochloric acid, and estimating the ammonia from the ammonium chloride formed. The albuminoid ammonia is got by washing it out of the air, and then determining it, as in water, by Wanklyn's method. The oxidisable matters are stated in terms of the amount of oxygen required to oxidise a solution of permanganate of potash of known strength. The presence of sulphuretted hydrogen is to be detected by lead acetate paper or solution. The humidity is found by Daniell's hygrometer, or the wet and dry bulb thermometer, p. 134. An idea of the suspended matter present is obtained by aspirating a spray of air on to the glycerine-coated surface of a glass plate, or by dissolving the air in distilled water and permitting sedimentation. Micro-organisms are detected and estimated by passing the air through a Petri's sand filter, washing the sand with sterile distilled water, and making plates from the washings. Simple exposure of gelatine plates to the air is a rough method of obtaining an idea of the nature of the organisms present. The details of the above processes are not stated, as, strictly speaking, they pertain to laboratory work.

Warming.—In testing the warming of a house, it is well to—

1. Note the temperature maintained under varying conditions.

2. Observe roughly the amount of fuel consumed for the heat produced, and the material and construction of all the fireplaces.

3. Mark the position and materials of any stoves, their connection with flues, and the course of these flues. It may be advisable to determine if any carbon monoxide is present, which is done by spectroscopic examination of hæmoglobin exposed to the air suspected of containing it.

4. If the house is heated by pipes, their general arrangement must be considered, the efficiency of safety valves, the situation of radiators, and the sufficiency or otherwise of pipe-heating surface employed. The boiler power may have to be determined, and by it is meant the extent of pipe surface in square feet, which the boiler will efficiently heat for each square foot of boiler surface. The following equation gives it—

$$\text{B.P.} = \frac{\text{Superficial boiler area exposed to direct action of fire} \times 58 \times \frac{1}{3} \text{ flue heated surface exposed to hot gases.}}{\text{Area in square ft. of the fire grate.}}$$

Lighting.—In testing the lighting of a house, the light employed should be noted. If electric, note if the light be sufficiently shaded ; if gas, observe the number of burners in common use, the means of removing their products of combustion, the nature of the burner, and the presence of any leakage. There is only one mode of testing leaks in gas pipes, and this is not the usual one of approaching the seat of smell with a light and departing in an explosion, but consists in plugging every burner but one, and to it attaching a tube with a force pump and gauge, the meter having been disconnected. Air is then pumped into the whole system of pipes. If, after working the pump for some time and then stopping it, the gauge does not fall, the conditions are satisfactory, If the mercury falls, there is a leak, which can be located by pouring a little ether into the pipe and pumping, or by lathering the outside of the pipe with soap and water, pumping, and observing bubble formation. It may be required to determine the sulphurous acid produced by impure gas imperfectly combusted. This is done by observing its action on a solution of iodine, and estimating by sodium thiosulphate the iodine consumed. As regards lamps, the variety of oil used, and its flash point, has to be noted, as well as the material of which the lamp is constructed.

Water supply.—In testing the water supply, mensuration is required for determining the capacity of any cistern, and attention must be paid to all those sanitary arrangements already fully discussed, and which need not be here recapitulated.

There remains for consideration the important subject of *Drain-testing*, with which the medical officer of health should be familiar, though he does not himself carry out the tests.

The drainage system of new houses should always be tested before occupation, and all houses should have their drains tested annually.

Hydraulic or water test.—This consists in subjecting the drains to a pressure of a head of water of 6 ft. for two hours, and is carried out as follows:—Block the lower end of the drain by a drain plug or air bag. This is best done at a convenient point, such as a disconnecting ventilating chamber, or just above a ventilating intercepting trap. To obtain the head of water, erect a pipe at the head of the drain, or use an Addison's (Fig. 177) or Jones' drain stopper.

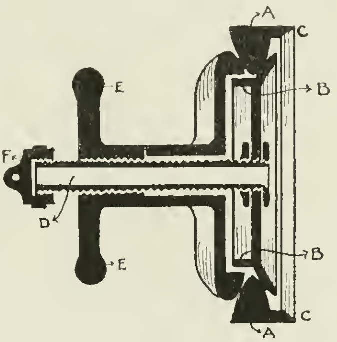


FIG. 177. — Addison patent drain stopper. *a*, Rubber ring. *b*, Guide. *c*, Projection of ring. *d*, Tube. *e*, Large screw nut. *f*, Screw cap.

Having filled the pipes with water, note the level at which it stands, and observe if, after two hours, there be any fall. If the system be a large one, it is better to test the sections separately.

The method cannot be employed on a rainy day. An objection to this test is that the pressure is not uniform at all points of the pipes or drains, being greater at their lower ends.

Pneumatic test.—Here air, instead of water, is used under pressure. The outlets are stopped as before, and air is pumped in by an Eclipse generator or other apparatus, such as Jensen's pneumatic force-pump, provided with a gauge or safety valve. Any fall of pressure in the pipes, due to leakage, is detected in the generator by means of a copper float on a water chamber in the apparatus. If it falls, a leak is present. In this test the pressure at all points of the system is uniform, and it can be conveniently applied to vertical pipes. Moreover, it is applicable in any weather.

Smoke test.—Smoke is forced into the drains by means of an Eclipse smoke generator (Fig. 178) or other apparatus. Oily cotton waste is burned in the generator, and the smoke is pumped along a special heat-resisting rubber tube which passes into the drain. The generator consists of a double action bellows and a copper cylinder acting as a fire-box and situated inside a copper tank filled with water. There is a copper cover or float over the cylinder, which forms with the water an air-tight joint. It is a useful apparatus; as used pneumatically it indicates the presence of a leak, and with smoke detects the position of the leak. The connection between the pipe and the drain can be made at any ventilating opening, gully, trap, or disconnecting pit. When smoke is seen to be freely issuing from the highest drain ventilators, all the drain ventilators are closed with damp cloths or special plugs. More smoke is then pumped into the pipes, and if there be any leak within the house, it makes its presence evident at that spot. Only sections of outside drains should be treated at one time.

Other methods.—Watt's asphyxiator may be used, in which "touch-paper" is the source of smoke, and a fan driven by a wheel supplies the draught. Tyndall's asphyxiator is very compact, and has very few working parts. Still another variety is the "Grahtryx" smoke machine, which also employs "touch-paper" and a fan and wheel. Smoke rockets may be employed, or Burnett's patent smoke drain tester, the drain being charged through the seal of the water-closet.

Peppermint test.—The ventilating pipes or shafts should be closed with damp cloths or clay. Then place $\frac{1}{2}$ oz. to 1 oz. of the crude oil of peppermint in the pan or basin of the topmost water-closet, gradually pour in 1 gallon of hot water, and discharge down the soil pipe. If the smell of peppermint makes itself felt elsewhere in the house, or outside along the line of the drain, some defect is indicated. For this test two persons are required, the one applying the test in the water-closet chamber, where he has to stay till it is finished, and the other searching for indications of a leak. The process is to be repeated in the lower water-closets and outside gullies. Instead of pouring the peppermint down a closet, it may be introduced into the top of the ventilating portion of the soil pipe, which is afterwards plugged.

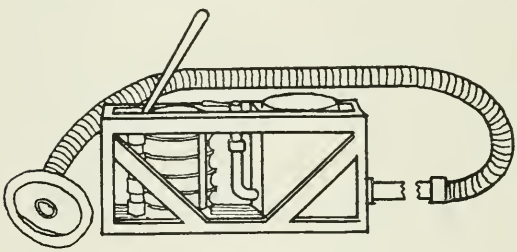


Fig. 178.—Eclipse smoke generator.

Banner's drain grenades of thin glass filled with pungent chemicals form another device for drain-testing, as does Kemp's drain tester, which acts by a combination of smoke and smell. The contents of the tester are washed down, and the case withdrawn by a string to see that the contents have all been expelled.

If a bad smell, apart from that of gas, be felt in a house, it may arise, if in the basement, from—

(1) A leaking or fractured drain pipe. Defective jointing is common, as is damage done by rats. (2) A disused brick-built drain. (3) A cesspool active or extinct. In a country-house a sink smell is usually due to an unventilated cesspool, the gases in which may be explosive. (4) A trap at the foot of the soil pipe. (5) Untrapped or unventilated waste-water gullies. (6) Bad trapping of drains or neglect of flushing. (7) If ammoniacal, a connection of the house drains with stable drains. (8) Dead animals. (9) Wood rot, wet or dry.

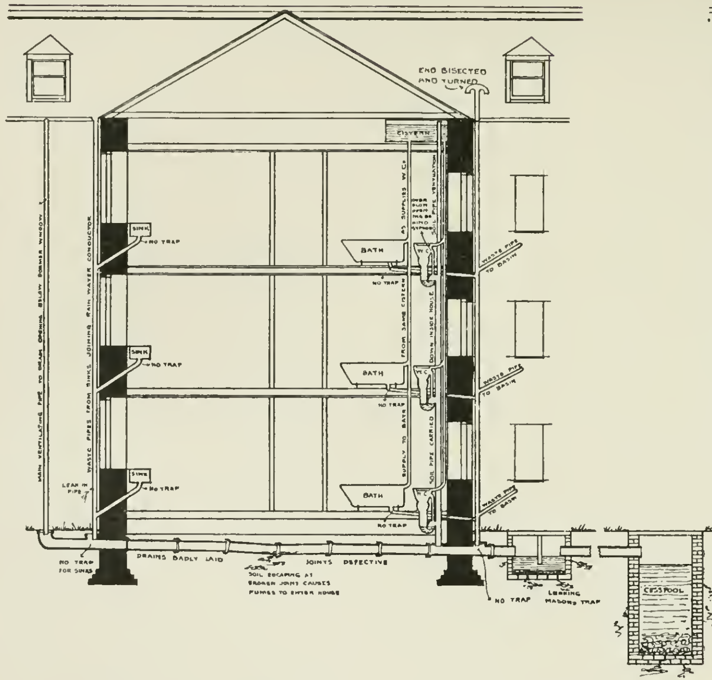


FIG. 179.

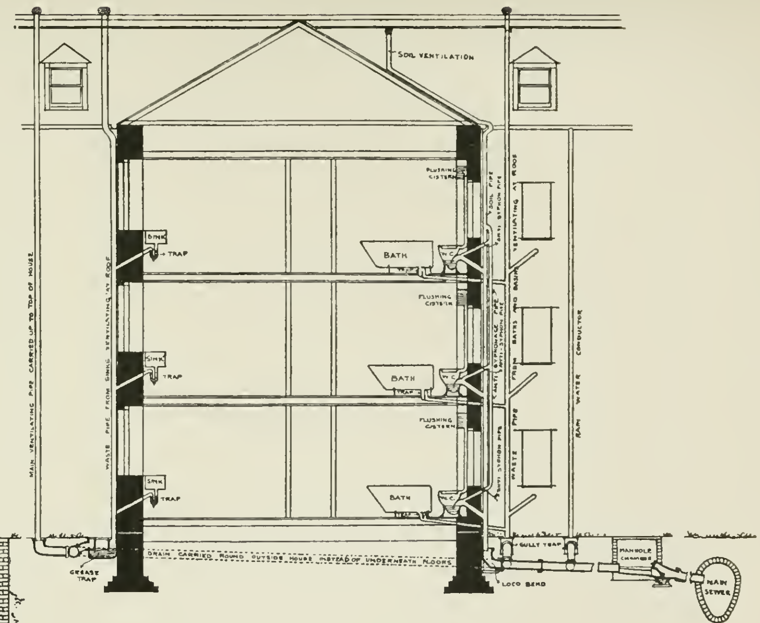


FIG. 180.

If in the bedroom floors, from—

(1) A burst, ill-jointed, badly-connected, or unventilated soil pipe. (2) The top of the soil pipe ventilator wrongly placed. (3) A bad type of water-closet, such as a pan closet. (4) General closet defects, such as leakage, bad jointing, syphonage of water traps, blocking of pipes, etc. (5) Rain-water pipes with wrong connections. (6) Putrid water in a cistern. (7) Dead animals. (8) Wood rot, dry or wet, and débris between floors and ceilings.

Drain smells may be simulated by those of disinfectants or vermin destroyers. A close, sweet odour often indicates grave defects.

Dampness may be local or general; if the latter, due to a wet soil and the absence of a damp-proof course, dry area, or layer of concrete. If the former, there may be a leaking water pipe in the wall, leaking drains, or the waste-water pipes or the rain rhones may leak or be too small, the roof may be defective, or the wall may be too thin or too porous. A point of some importance is that poisoning from gas may take place in houses as the result of leaky gas mains, the gas being sucked into the houses owing to the temperature of the air in them being higher than that of the atmospheric air. The gas may lose its smell in its passage through the soil, and hence is doubly dangerous. Such an accident is most liable to occur in winter, when the superficial layers of the soil outside the house are frozen. The leak may be a considerable distance from the house, even 30 or 40 yds., under such conditions.

In Fig. 179 is shown a house with numerous defects in its sanitary arrangements, and in Fig. 180 is delineated the same house with many of the defects remedied.

VII. THE CONSTRUCTION AND ARRANGEMENT OF HOSPITALS, SANATORIA, SCHOOLS, WORKMEN'S DWELLINGS, COW-SHEDS, AND SLAUGHTER-HOUSES.

HOSPITALS.

From a public health point of view, hospitals may be classed as—(1) non-isolation hospitals; (2) isolation hospitals.

Certain general rules apply to the first variety.

The site must possess all those advantages already described as being required for a dwelling, and, in particular, ample surrounding space, good drainage slope, free air circulation, and abundance of light should be obtained wherever feasible. It is advisable that the site should admit of future extension of the buildings, and it ought to be readily accessible from any part of the district which the hospital is intended to serve, and at the same time as remote as possible from noise and traffic. A large hospital and its dependencies covers about 120 square yds. for every bed it provides. The building should be so placed that any long wards receive a fairly equal amount of sunlight on both sides. They should therefore face east and west, or, if this is impossible, south-east and north-west. A well-equipped general hospital should possess an administrative block, wards and their adjuncts, accommodation for out-patients, for operative procedures, for special departments, including an observation ward, mortuary, and post-mortem room, housing for the staff, a laundry, kitchen, and buildings to contain the ventilating, heating, and lighting plant, if these be provided.

The administrative block and staff premises should be separate from the wards, medical and surgical wards should be kept apart, the laundry, mortuary, and post-mortem room must be as far as possible from the wards and in a special building, while there should be no direct connection between the wards and the out-patient department. The whole arrangement should be such as to conduce to easy working, the main parts of the building being connected by covered corridors, which should be well lighted, warm, and cross-ventilated. It is scarcely necessary to add that special wards must be provided for each sex. As regards the wards which hygienically constitute the most important portion of the hospital, these are best when only a single storey high, as air circulation is thus favoured, and the necessity for stairs is avoided. Such ward construction is, however, impossible in a large hospital, owing to expense and the limited available land, and two or three storeys are usually built. Large wards, containing twenty-four to thirty-two beds, are advisable in nearly every respect, and especially as regards convenience in nursing. In shape they may be rectangular, circular, or octagonal. The long rectangular ward is that most commonly in vogue, but the circular form possesses several advantages, such as easy inlet of light and air, fewer corners for the lodgment of dust, facilities for nursing and general management, and greater area for length of wall, but much of the area so obtained is wasted, and cannot be utilised without obstruction to cross-ventilation. If a circular ward is to contain the same number of patients as a rectangular ward of equal floor measurement and cubic contents, the beds require to be closely approximated, and sufficient wall space per head is not forthcoming. What is known as the disconnected pavilion system is much the best, and care must be taken that the staircases do not ventilate one ward into another.

A certain distance should separate neighbouring pavilions, and a useful rule to remember is, that this distance should be approximately three-fourths of the combined height of the adjacent pavilions. The provision of fresh air to the patient is the most important requisite in hospital construction; adequate space must be allotted each bed, and the air of the wards periodically renewed. Serious surgical cases, and phthisical and pneumonic patients, require more than the average space, which may be taken as 120 square ft. of floor area, 1500 cubic ft. of air space, and 8 ft. of wall space for each bed. The wards should be 12 to 15 ft. high, and the beds should be so arranged in it that there should be a window between two adjacent beds, and the heads of the beds should be placed against the wall. The wall space between the windows, against which the head of each bed is placed, should be 1 to 2 ft. wider than the bed, in order to protect the patient from draught. Natural ventilation is the cheapest and most efficient means of providing unlimited fresh air; it is also most easily regulated in individual wards without interference to the supply of other wards. The object is to obtain as much fresh air as possible without the production of draughts, and the hourly supply of fresh air should be at least three times the cubic capacity of the ward, or about 3000 to 4000 cubic ft. per head per hour. Fresh air must be provided also for the nurses and others using the wards; and where clinical classes are held in them a large extra supply is required. The window area should be 1 square ft. for every 70 to 80 cubic ft. capacity of the ward, and the windows should face each other and reach to within 1 ft. of the ceiling. Where natural ventilation is employed, the upper part of the window should be made to open, and supple-

[*Continued on page* 402.

ROYAL INFIRMARY EDINBURGH

BLOCK PLAN

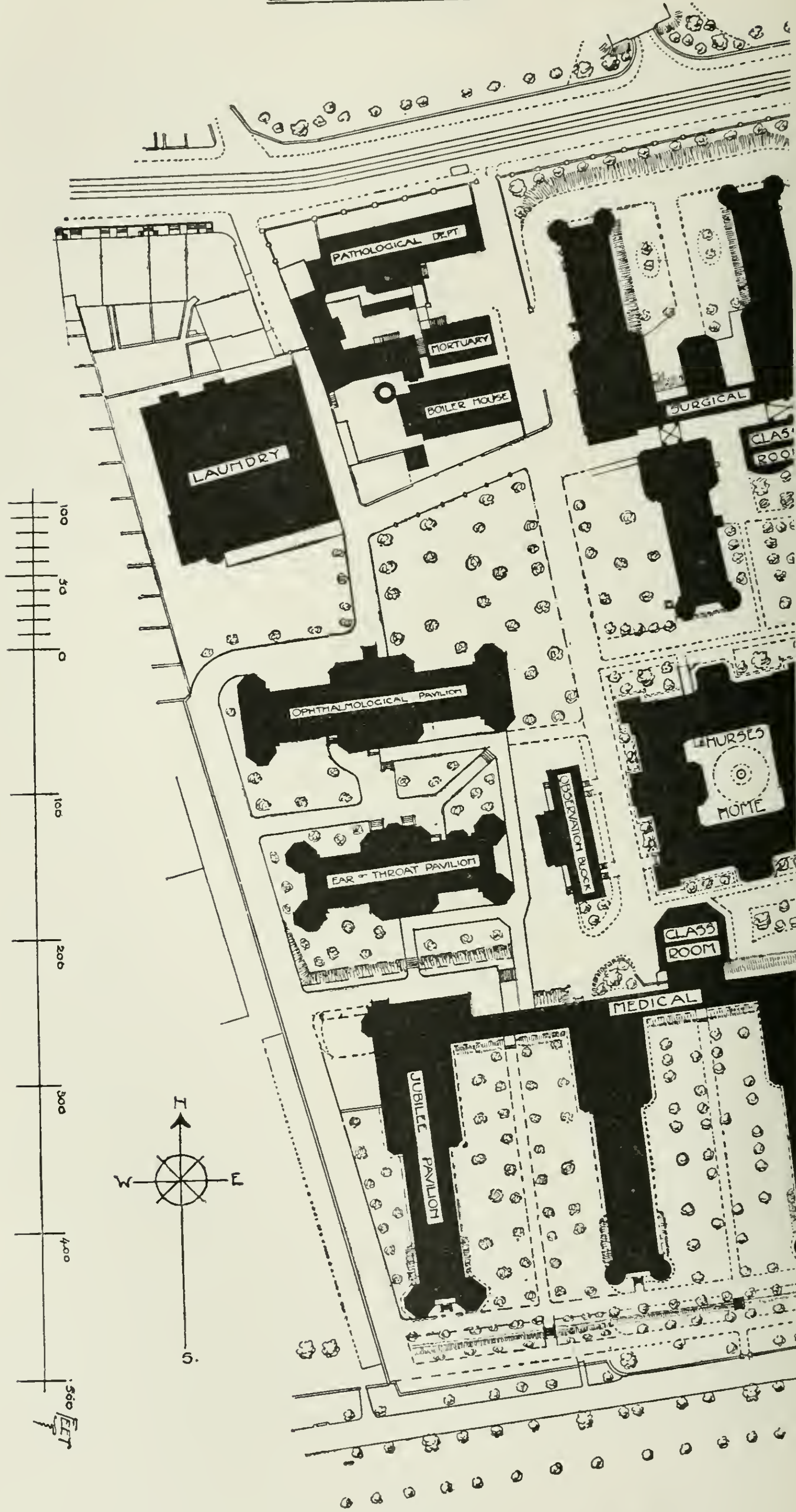


PLATE VII.

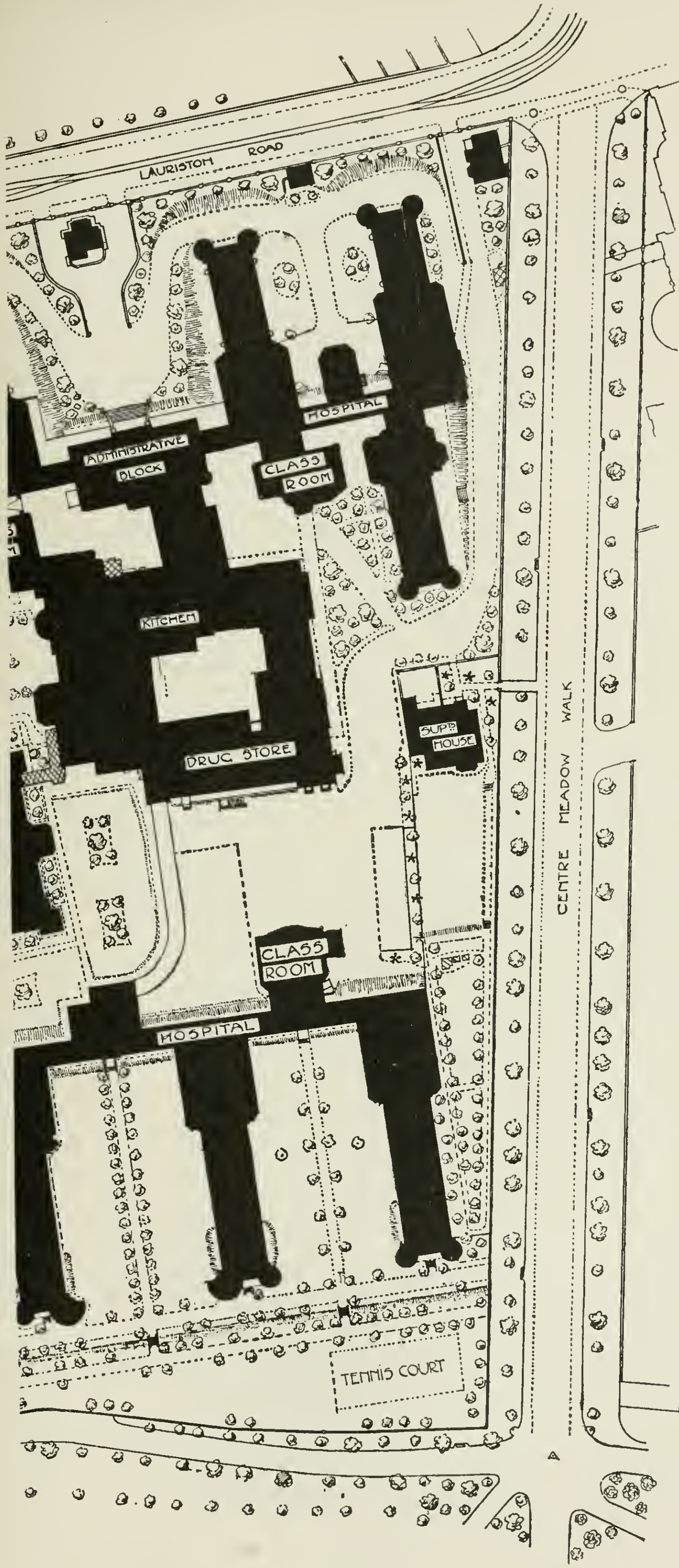

LAURISTON ROAD
HOSPITAL
ADMINISTRATIVE BLOCK
CLASS ROOM
KITCHEN
DRUG STORE
SUPT'S HOUSE
CENTRE MEADOW WALK
CLASS ROOM
HOSPITAL
TENNIS COURT

PLATE VII.

mentary inlets may be provided by means of Sheringham's valves or Tobin's tubes. A special inlet is provided in the wall near the head of each bed and about 1 ft. from the floor, to ventilate the space under each bed. Extraction is provided for by the open windows, by fireplaces or stoves, by shafts surrounding or alongside the chimney or flue, or by special shafts. In winter the fresh air supply may require to be warmed, and this may conveniently be done by ventilating fireplaces, radiators, etc. Equable warming of the wards is best effected by means of hot water or steam pipes running round them, or laid beneath the floor if it be not of wood; an open fire assists ventilation and provides cheerful warmth. Mechanical ventilation in hospitals should be provided on the Plenum system, by which the air can be taken from a chosen source, treated before admission, and its supply regulated to each ward. Ward floors should be fireproof, free from crevices, and so treated as not to require washing. If painted or stained and varnished, they can be oiled and beeswaxed, or they can have paraffin ironed into them, and then present a smooth surface which only requires brushing, and lasts for years. The walls must be as smooth and impermeable as possible, and these conditions are best attained by the use of fine plaster or glazed brickwork or tiles set in Portland cement. Ceilings may be cemented or lime-washed. All sharp angles and crevices are to be avoided by rounding off and filling up as required. There should be no hangings, and furniture should be reduced to a minimum. Hospital bedsteads should be of iron and have spring mattresses, and the hair mattress should be made in three sections. Water-closets and slop sinks should be separated from the ward by a cross-ventilated lobby, and are usually placed at the end of the ward remote from the entrance. Here also the bathrooms and lavatories are usually found, the floor of the bathroom being best constructed of impervious material, such as "mischiati," which consists of little cubes of marble laid without reference to pattern.

In this country the water-carriage system is the only one admissible for the removal of excreta from hospitals, and the water-closet chamber should be directly ventilated into the open air.

Doulton's improved hospital sink is specially designed for cleansing bedpans and urine bottles, being provided with a jet and valve below the flushing rim, and, in addition, a useful rising spray. The sink itself is flushed by a syphon cistern. The ward nurse should be provided with a room opening off the passage between the ward and the main corridor, and having an inspection window overlooking the ward. There should also be a ward scullery or small kitchen opening off the same passage. A verandah on the south or west aspect of the ward is a useful adjunct.

Plate VII. shows a block plan of the Edinburgh Royal Infirmary, with its most recent additions, which make it one of the largest and most modern in the kingdom. Fig. 181 is a photograph of a large general military hospital of nearly 1000 beds, in time of war.

Isolation Hospitals may be permanent or temporary. Much that has been said as to the general hospital applies also to the permanent isolation hospital, but some special rules are applicable to the latter. A larger space is required for an isolation hospital than for a general hospital of the same size, and the seclusion of the site by a high wall, at least 6 ft. 6 in. in height, should be a sine quâ non. An isolation hospital need not be so accessible as a general hospital, but may conveniently be placed in sparsely populated

FIG. 181.—South African General Military Hospital.

suburbs. The size of hospital required may be stated as one bed per 1000 inhabitants of an industrial town, or town with a mixed population. In addition to the component parts enumerated under General Hospitals, an isolation hospital must have a regular disinfecting station, an incinerator, an ambulance yard, and stables. There should be large recreation grounds available, and so divided that contact between convalescents from different diseases can be avoided. Each disease should have its separate block, or blocks, absolutely disconnected, and at least 40 ft. apart; and no block should be nearer the boundary wall than 40 ft. The administrative block should be separate from the patients' quarters, and there should be no sleeping accommodation near the wards themselves for the nurses connected with them. Small wards for the observation of doubtful cases form useful adjuncts to the larger wards. The one-storey pavilion system is undoubtedly the best, though two-storey buildings may be allowed, and a flat roof may be utilised for exercise if ground be limited. The typhus pavilion should occupy a position specially remote from other pavilions, and no provision is to be made for smallpox cases, which must have a special hospital provided for them. Ventilation, lighting, heating, and sanitary conveniences may resemble the similar methods and appliances of a general hospital, but a larger area is required per bed, namely, 140 to 200 square ft. of floor area, and 2500 to 3000 cubic ft. of space; 12 ft. of wall space is also necessary. The Local Government Board recommend 1 square ft. of window area to every 70 cubic ft. of ward space. Double-hung sash windows, with fanlights made to fall inwards, and with side checks to prevent down-draughts, are useful. Typhus and measles wards require a larger area per bed than scarlet and typhoid fever wards. Vitiated air may be extracted and conducted to a furnace, or made to pass through canvas screens, being at the same time subjected to the action of a disinfectant. In hospitals where two-storey pavilions are used, sanitary towers may be provided at the side of the pavilions, separated from them by cross-ventilated lobbies. These contain the closets, slop sinks, and other conveniences, including a shoot for dirty linen, which falls into a carbolic tank, instead of having to be carried downstairs. The bathrooms and lavatories are separated from the sanitary towers, and are provided for each ward. Fresh air balconies and special sunny rooms should be set aside for convalescing cases. For each pavilion there must be arrangements for the discharge of patients, consisting of a bathroom and a dressing-room, the latter having an exit to the open air. A nurses' dressing-room is essential, a small separation ward is useful, and in enteric and diphtheria pavilions an operating-room adjacent to the wards should be provided.

Plate VIII. shows the new Edinburgh Hospital for Infectious Diseases, which contains over 600 beds, there being 15 patients to the acre, and is constructed on the most approved modern principles. (See Plates IX. and X., pp. 406, 407.)

Examples of small isolation hospitals on the Local Government Board pattern are shown in Figs. 182 and 183.

Temporary Isolation Hospitals are adapted for combating an epidemic, and are not so solidly constructed as permanent hospitals. They may be used to provide for the overflow of cases from a permanent hospital during epidemics, or may be erected in the country to meet village requirements. Wooden huts having double walls filled with sawdust, or galvanised iron huts, or tents, may be used. Waterproof material stretched on wooden frames forming huts of

[*Continued on p.* 408.

EDINBURGH CITY HOSPITAL—COLINTON MAINS.

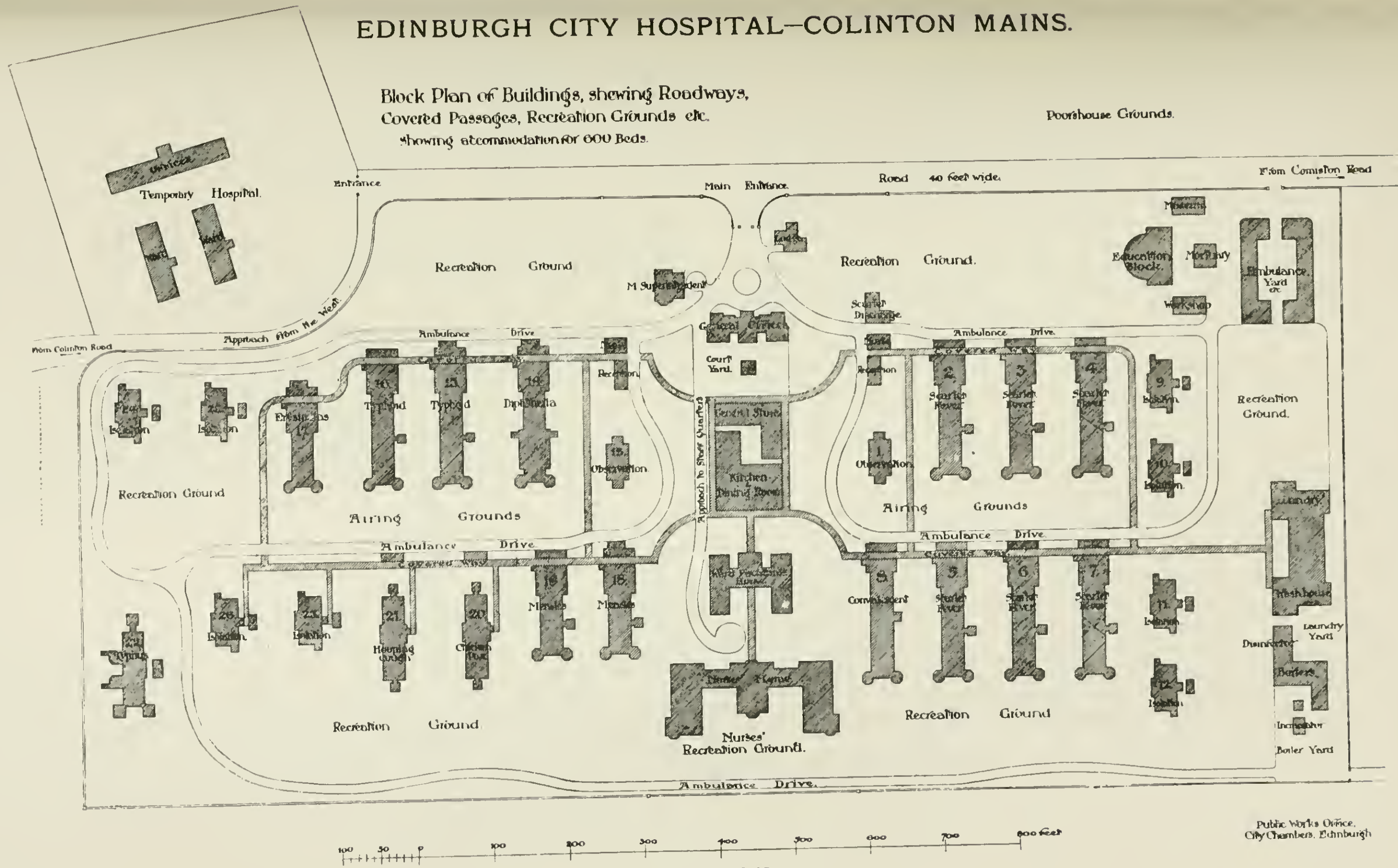
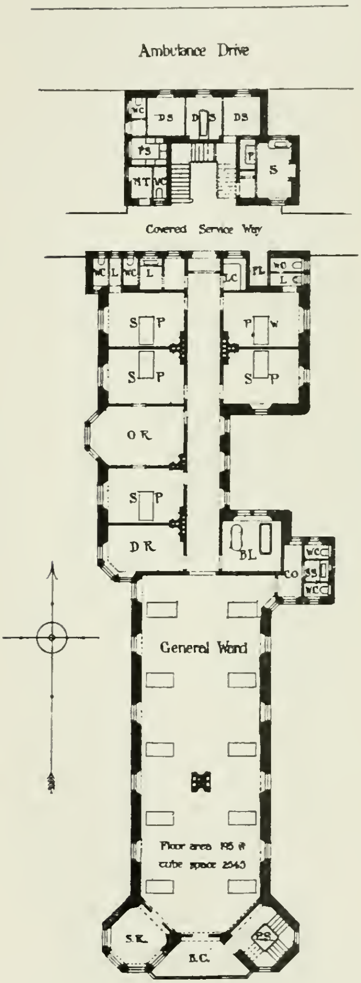


PLATE VIII.

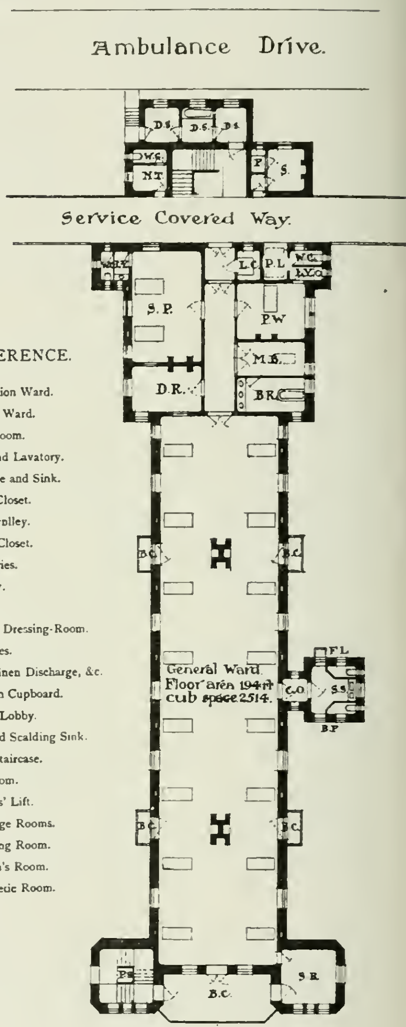
EDINBURGH CITY HOSPITAL

WARD PLANS.

DIPHTHERIA.
No. 14 on Ground Plan.



TYPHOID.
Nos. 15, 16 on Ground Plan.



REFERENCE.

S.P. Separation Ward.
P.W. Private Ward.
D. Duty Room.
B.L. Bath and Lavatory.
M.B. Movable and Sink.
L.C. Linen Closet.
C.T. Coal Trolley.
W.C. Water-Closet.
L.Y. Lavatories.
S. Scullery.
P. Pantry.
N.T. Nurses' Dressing-Room.
B.Y. Balconies.
F.L. Foul Linen Discharge, &c.
B.P. Bed Pan Cupboard.
C.O. Cut-off Lobby.
S.S. Slop and Scalding Sink.
P.S. Panic Staircase.
S.R. Sun Room.
P.L. Patients' Lift.
D.S. Discharge Rooms.
O.R. Operating Room.
S.R. Surgeon's Room.
A.T. Anæsthetic Room.

Scale

PLATE IX.

IMPROVED DISCHARGING BLOCK.

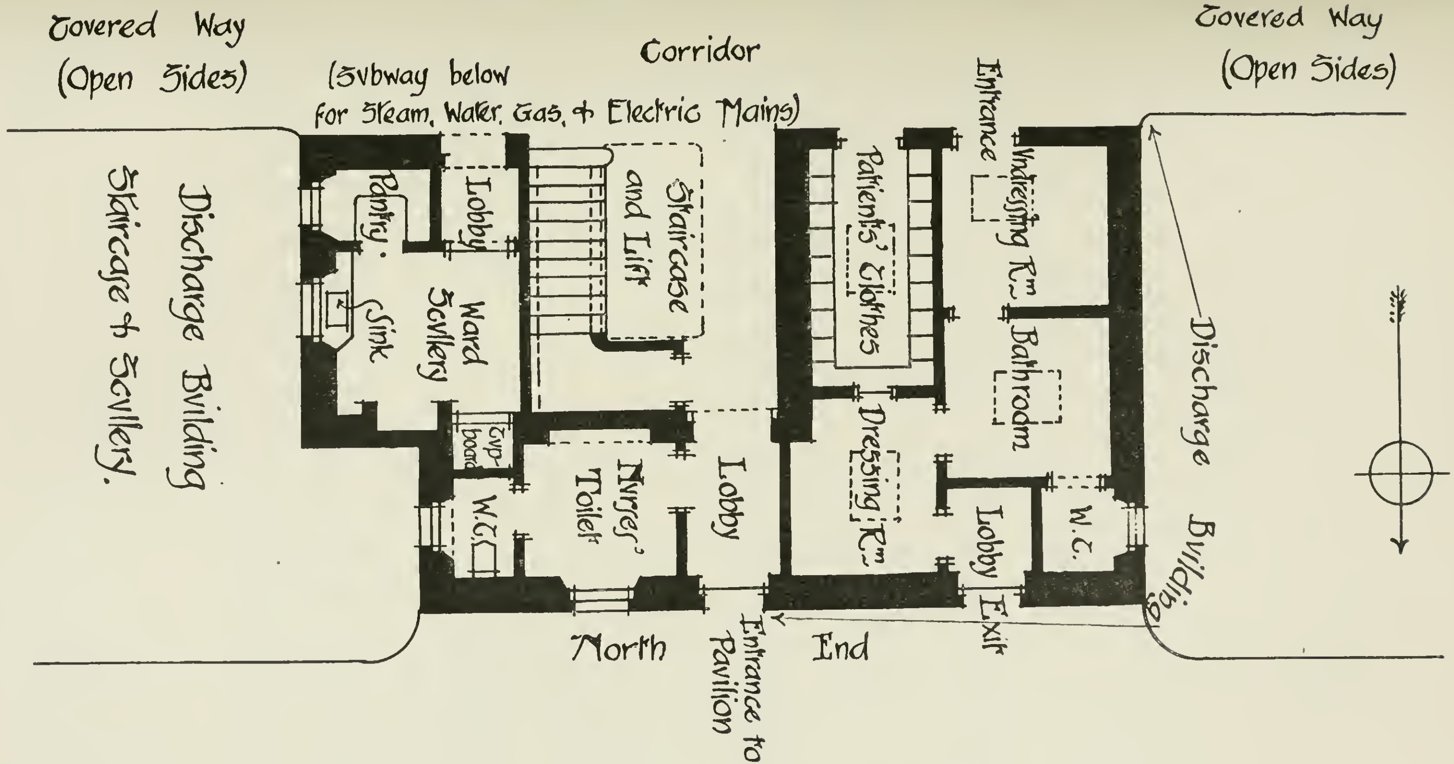


PLATE X.

the Doecker or Ducker type may be employed, and Willesden waterproof paper is also available. The huts should be raised above the ground, may be partly ventilated on the ridge-roof system; and after use the wooden forms may be burned, while the iron ones can be disinfected. Not more than

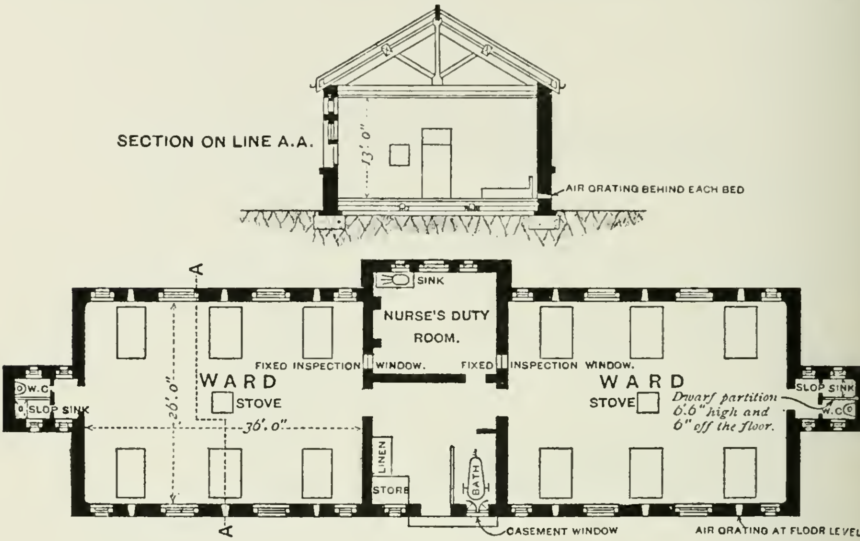


FIG. 182.

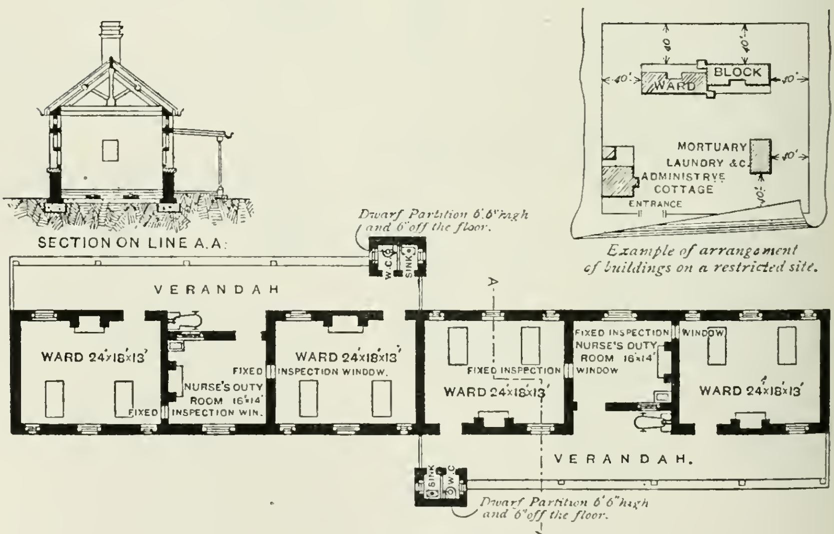


FIG. 183.

twenty persons should be accommodated on one acre of land. The disadvantages of such temporary hospitals are that, though cheap and easily erected, they are less comfortable, more difficult to ventilate and to regulate as regards heat and cold, less durable, and less easy to disinfect in most cases, while they have not the perfect appliances for preventing communicable disease. An ordinary isolation hospital has no great tendency to spread disease, and it is notable that no excess of cases are admitted into the present Edinburgh City Hospital from the immediately surrounding houses; but with hospitals to which smallpox is admitted there is great danger of dissemination, and, consequently, smallpox hospitals must be remote from any populous neighbourhood. With a view of lessening the risk of infection, the Local Government Board have suggested that the local authority should not contemplate the erection of a smallpox hospital—(1) Upon any site where it would have within a quarter of a mile of it, as a centre, either any hospital, whether for infectious diseases or not, or a workhouse, asylum, or any similar establishment, or a population of as many as 200 persons. (2) On any site where it would have within half a mile of it, as a centre, a population of as many as 600 persons, whether in one or more institutions or in dwelling-houses. (3) Even where the above conditions are fulfilled, a hospital must not be used at one and the same time for the reception of cases of smallpox and of any other class of disease.

General Regulations for Isolation Hospitals.—Nurses should not attend cases of different diseases at one time, and those nursing different diseases should, as far as possible, be prevented from mixing when off duty. This is specially important in the case of those tending scarlet fever patients. Doctors should wear fresh overalls in each pavilion, and be careful as to the disinfection of their hands, etc. No member of the staff should leave the hospital without having changed outer garments. Domestic animals should not be kept in the hospital. Visits from friends should be brief, and should be only permitted in the case of intimate friends and relatives in the presence of serious illness; overalls must be provided for visitors, and ablutionary precautions insisted upon. No visitor should be permitted to enter a smallpox hospital who has not had the disease, unless he has been recently vaccinated, or is willing to undergo immediate vaccination prior to seeing the patient.

The subjoined table gives the cubic space per head provided in the various wards of the new Edinburgh Hospital for Infectious Diseases.

Ward.	Space in Cubic Feet per Head.
Chickenpox	1690 (chiefly for children).
Diphtheria	2545
Enteric fever	2514
Erysipelas	2028
Measles	1690 (chiefly for children).
Scarlet fever	2000
Typhus fever	3042
Whooping-cough	1690 (chiefly for children).

In smallpox wards the cubic space per head should be at least 3000 cubic ft.

Hospital Staffs.—In a small isolation hospital, containing, as a rule, about a dozen patients, and capable of containing two or three times that number, the permanent staff required consists of a visiting physician, a resident matron, a probationer, one or two ward-maids, and one male attendant, who drives the ambulance, attends to the stables, garden, mortuary, disinfecting apparatus, etc. When cases of more than one disease are admitted, it is necessary to supplement the nursing staff. The usual plan is to engage nurses from a nursing home with which the hospital has an agreement. Such an hospital as the above requires more servants if it be heated by fireplaces. In a medium-sized hospital of from 50 to 150 beds there is usually a medical superintendent, who is the medical officer of health in many cases. Under him are a resident physician, matron, and a male staff of about six, *i.e.* lodge-keeper and porter, engineer, disinfecting attendant, ambulance driver, gardener, night fireman and watchman. A separate gardener is not always required. The matron superintends the ward staff, consisting of nurses, probationers, and ward-maids, the domestic staff (kitchen, etc.), and the laundry staff (domestic and hospital departments). In a large hospital, such as the new Edinburgh Fever Hospital, a resident medical superintendent is necessary, several resident physicians, a pathologist and bacteriologist, lady superintendent, housekeeper, assistant superintendent, and a large nursing staff, there being a nurse for every four beds. At least sixty female servants, including laundry-maids, are necessary, and a staff of at least twelve male servants.

SANATORIA.

These, in the common sense of the term, are hospitals for the open-air treatment of tuberculosis. There are also sanatoria for malaria, but these owe their value rather to their geographical situation than to their construction, while the former present certain peculiarities in their arrangements and adjuncts which require brief notice.

Situation.—A sanatorium should possess, in an exalted degree, all those ideal characteristics of site and aspect already considered in reference to the ordinary dwelling-house. A sanatorium may be situated in an elevated district, preferably in proximity to pine forests. This, fortunately for the poorer class of patients, is by no means absolutely necessary, and, indeed, there is an advantage in accomplishing the cure under the same climatic conditions to which the patient has been accustomed, and amongst which he must live after cure. There are two sanatoria within three miles of the centre of Edinburgh, a city not famed for its genial weather conditions, in which excellent results are obtained.

Surroundings.—Fairly extensive private grounds are indispensable, and the planting of trees is advisable to break the force of wind, to aid in the drying of soil, and to add to the cheerfulness of the environment. It is an advantage if the site be protected by the configuration of the land from cold or boisterous winds, but such barrier should not be so close as to interfere with the free circulation of air.

Main Buildings.—As the result of many years' experience, Dr. Philip believes the best type of building to be a collection of pavilions, one storey in height, and each of winged form, the obtuse retreating angle between the wings facing due south. Each wing constitutes a separate ward. Access to the pavilion is obtained from behind into a passage with doors opening into the wards. From this passage a short projection northwards contains the bath-rooms and lavatory accommodation. The intervening triangle between the wards and passage is utilised as a nurses' day-room. Opening off the passage are two small cloak-rooms for patients' clothes. A simple cooking apparatus may be provided in the nurse's room for preparing the food of such patients as are confined to bed. The dining-room for other patients and the kitchen are best placed in a building in or near the administration block, which should be entirely apart from any pavilion, without connecting corridors. Adjacent pavilions should be at least 40 ft. apart. Each pavilion may contain accommodation for eight to twelve patients, and should be so oriented as to secure ample air and a maximum amount of sunlight for the two wings in which patients are lodged. The pavilion should be raised on pillars to a height of 3 feet above the ground, so that air may circulate freely beneath it. The building material should be of brick or stone, and, as regards the walls, there should be as many windows as can be inserted in them. Balconies and verandahs are probably best avoided, since they tend to interfere with free air perflation throughout the building, and to throw parts into shade. The south angle is of use, as its sides afford shelter to weakly patients moved out into the open air close to the pavilion. Hinged screens may, if necessary, be attached to the ends of the wards to further shield from wind. Internally, the wards should in all respects conform to those of a modern isolation hospital as regards smooth surfaces, absence of angles, and unnecessary furniture. Electric light should be employed, and no steam or hot-water pipes should traverse the building. An open fire may be provided, not so much for heating purposes as to promote cheerfulness and aid ventilation. Indeed, the ward temperature is not to be kept at any fixed point, but should approximate to that of the outer air, except perhaps in the coldest weather. The windows are best made of the French type, opening outwards. They are to be kept constantly open, both day and night. By this means extremely free air perflation is maintained, and the air of the ward is practically never vitiated. The cubic space per bed should be about 1200 cubic ft., but the air is so frequently changed that this amount need not be insisted upon. The height of the wards need not exceed 12 ft., and there should be about 100 square ft. of floor area for each bed. As the use of baths forms an important part of the treatment, these should be numerous, there being one bath provided for every four patients.

Subsidiary Buildings.—These take the form of shelters in the grounds, in which patients pass most of the day, while they may even be allowed to sleep in them. They may be made to revolve, but if a sufficient number be available, and so distributed in the grounds as to face every way, the shelters may be stationary. In a public sanatorium this is often advisable. The two essentials of such shelters are—(*a*) they should be shallow, being only of sufficient depth to accommodate the width of a couch,—3 to 4 ft. is usually ample; (*b*) the roof should slope from behind upwards and forwards, to prevent the accumulation of stagnant air beneath it. Glass may with advantage enter largely into their construction. The shelters should be entirely open to the front, and may be provided with a ventilator in the back or roof. Only a limited number of patients should at one time use any one shelter. Hooded wicker chairs form useful supplementary shelters.

The above notes describe the plan of the new portion of the Victoria Hospital for Consumptives, Edinburgh. It will be apparent that the chief object of a sanatorium is to provide a hospital where patients can live under favourable hygienic conditions, and practically spend their whole time in the open air.

SCHOOLS.

Of recent years much has been done to improve the hygiene of schools (see p. 285). A school should, if possible, be situated in an open space, so that there may be ample light and air. The fresh air supply to be provided per head is large, since children for their weight exhale more carbonic acid than adults. 150 cubic ft. of space, 15 square ft. of floor area, and 1500 to 2000 cubic ft. of fresh air per hour, should be provided per head. The minimum requirements of the English Education Department are much below these amounts. Schoolrooms are best constructed of an oblong shape, and, when not lighted from the roof, may advisedly be placed in such a direction that, while fully lighted, they are not subjected to bright sunshine. The windows should reach to the ceiling, and, unless mechanical ventilation is installed, they should be made to open at the top. The window area should be at least one-tenth, and should not exceed one-fourth of the floor area. Natural ventilation is rarely sufficient for schoolrooms, and mechanical systems, with the use of fans, are generally needful, as shown by Carnelley, Haldane, and Anderson. The fresh air supply must be ample, and delivered at a suitable temperature, warm in winter, and cool in summer. We annex diagrams (Figs. 184, 185, and 186) showing an installation of the Leicester Plenum system, fulfilling these requirements and demonstrating the means by which the temperature of the air supply is regulated. The heating is best conducted by hot-water pipes, and the temperature should be maintained at 60° to 65°. The ceiling should be whitewashed, the walls of a quiet colour, and so constructed that they can be washed, and that they are free from projections and recesses. Floors should be of hard wood, and cleansed daily. Desks should run in parallel rows at right angles to the windows, and, like hospital beds, should, where possible, occupy the space in a line with the wall between two adjacent windows. The height of the desk above the seat should permit a child, when sitting, to rest both forearms comfortably upon it without hunching or drooping of the shoulders. The desk should

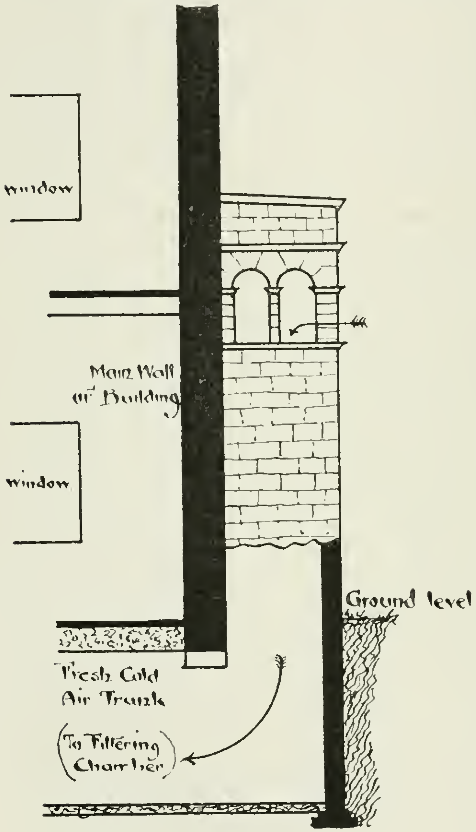


FIG. 184.

be sloped at an angle not exceeding 20°, *i.e.* the vertical distance between the upper and lower edges of the desk should be about 3 in. It is well if the angle of slope of the desk can be altered for writing and for reading. The

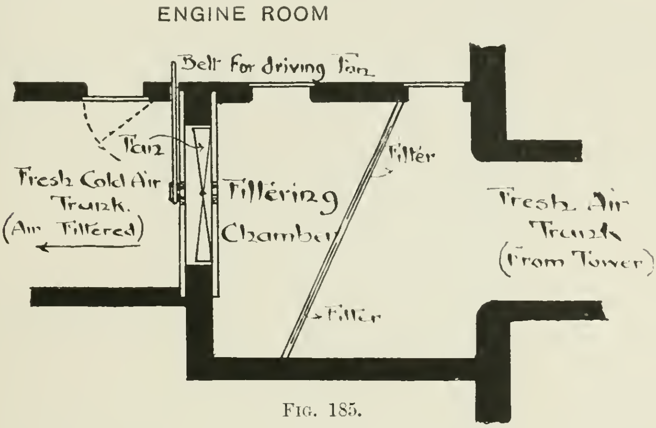
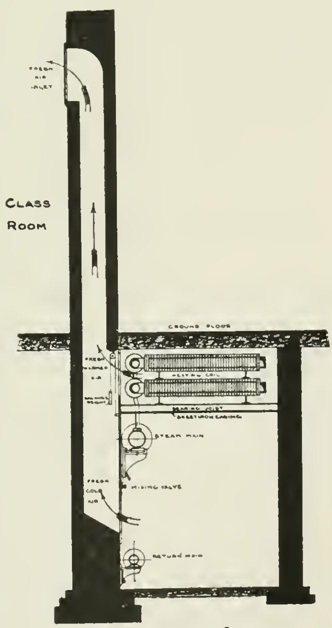


Fig. 185.

seat should be fitted with a back, which may advantageously be hollowed and padded to provide better support. The height of the seat above the ground should be the same as the length of the scholar's leg from the sole of the foot to the knee, and the breadth of the seat should not be less than 8 in. The horizontal distance between the edge of the seat and a vertical line dropped from the near edge of the desk should not exceed 1 in., and it is well if this relation can be adjusted, according as the desk is being used for reading or writing. The height from the seat to the desk should be one-sixth the height of the scholar. A school-room should be provided with desks of varying proportions, to meet the requirements of larger and smaller scholars, and hygienic desks devised by Priestley Smith fulfil these objects. The strongest light should fall on the desk from the left or left front of the scholar, and artificial light should, as far as possible, be avoided; but if it must be used, electric light or incandescent gas is best. Blackboards should not be polished and shiny, but of a dull black colour, so as not to reflect light and thereby induce eye-strain. For the same reason they should not be set between windows, and only white or yellow chalk should be used for writing on them. School dormitories should never be used as places for study, and should contain 600 to 800 cubic ft. of space per head. A good cloak-room is essential for every school, and there should be a recreation ground with covered sheds

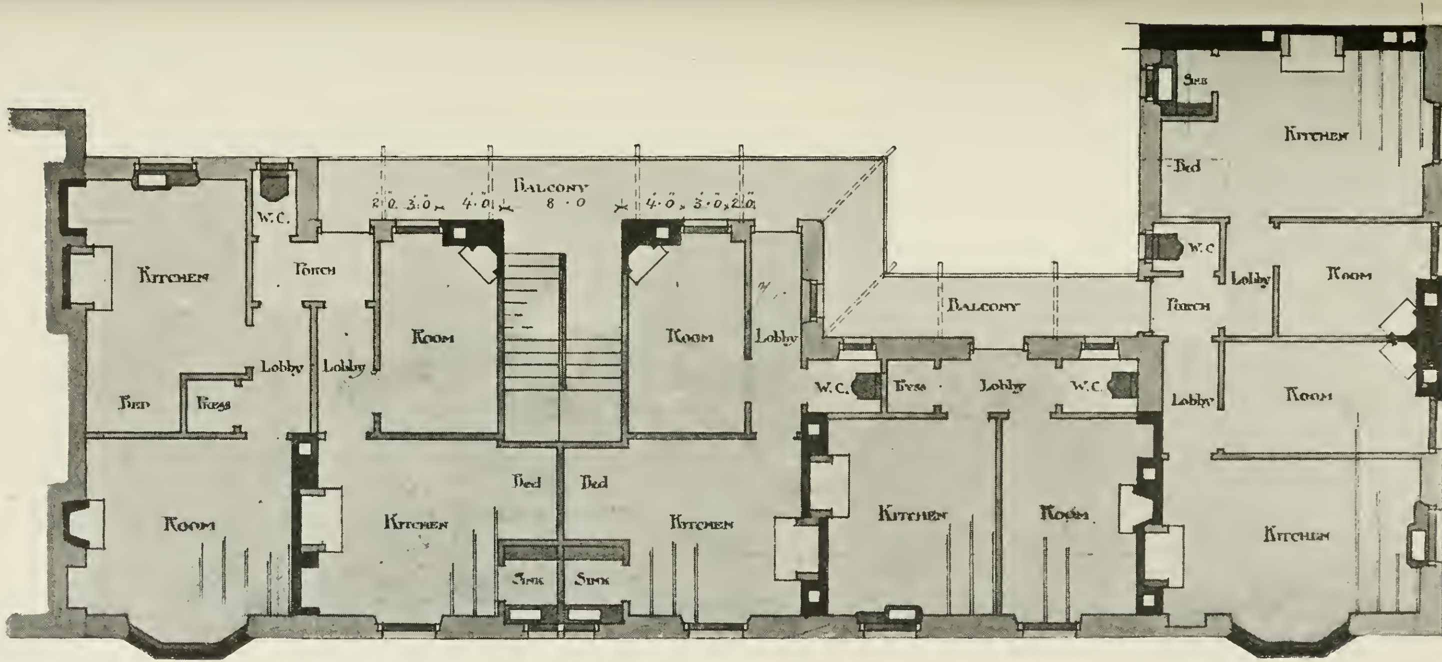


Transverse Section
Fig. 186.

for use in wet weather. Lavatories should be provided, the habit of daily washing inculcated, and the use of roller towels forbidden. As regards bathing, a French authority recommends that every child should have a bath once a fortnight, or as, he ingenuously adds, perhaps even "once a week, as is the custom in England!" Dry systems of sewage disposal do not work well in schools, and trough closets provided with an automatic flush are most suitable. The extent of water-closet accommodation required will vary with the sex of the scholars, more being required in girls' schools than in boys' schools, where urinals are also provided. From five to ten closets and five urinals should be provided for every 100 scholars.

WORKMEN'S DWELLINGS.

Improvement in the dwellings of artisans and labourers, especially those forming lofty blocks in the crowded parts of large towns, is a measure especially conducive to the health of the inhabitants and the prevention of the spread of disease. Such houses are often found in high tenements facing each other, and only separated by a narrow street or lane. This tends to shut out light and air from the lower storeys, and the condition is aggravated if the street or lane end in a cul-de-sac. The individual tenement blocks may be built round a court, the only access to which is a restricted passage or covered archway, and the result is that the air of the court is foul and stagnant, and those rooms the windows of which open upon it are sunless and ill-ventilated. Too often the houses themselves are arranged back to back, without any provision for free perflation of air, the proper storage of food, or the sanitary needs of their inmates. A steep, dark, dismal, dirty internal stair is frequently the only means of access to the houses in the block, which commonly teem with life of many varieties. Much attention has of late years been directed to the thinning or clearing out of insanitary areas and the erection of properly constructed lodgings for the working classes, and important legal enactments bear upon the subject. It is a difficult problem to arrange one- and two-roomed houses in a block so that all may have an equal amount of light and air, and to provide an inside staircase which shall not be gloomy and ill-ventilated. Blocks of buildings should never exceed five storeys in height, nor be more lofty than the width of the street on which they abut. An open space must be left at the rear, which must extend along the whole width of the building. At least one-half the site should not be built upon at all, and any court or yard should be properly paved and drained. Where possible, an outside staircase should be provided, but an excellent alternative plan is to break up an internal staircase by bringing it out upon balconies at the level of each storey, and in its intermediate parts providing openings to the external air, either in the shape of windows or permanently open "outlooks." A ventilating skylight should be placed in the roof at the top of the stair-well. The house doors should open directly on the stair landings, or preferably on the balconies, where such exist. The staircase should be of stone or concrete, and should be as wide as possible. As regards the separate houses, each room must have a window opening directly to the external air, and such window should be carried up nearly to the ceiling, and made to open top and bottom. Internal lobbies should be avoided, but, if present, may be ventilated by a fan-



PLAN OF 1ST AND 2ND FLOORS

PLATE XI.

light placed over the external door. On an average, rooms should contain 1500 cubic ft. of space, kitchens and living-rooms being somewhat larger than bedrooms. A good plan is to have external meat safes, and to do away as much as possible with the storage of food inside the rooms. No room must be without a fireplace, which is too often placed so as to economise space at the expense of the heating power of the fire. Where water-closets are provided, each should communicate directly by a window with the external air, and be so placed as not to ventilate into rooms. In Plate XI., which represents a plan of workmen's tenements recently erected in Edinburgh, there are four closets to six houses of two rooms each. A study of the figure shows that the placing of houses back to back has been carefully avoided, while it is possible to obtain a free perflation of air right through the block if doors and windows be opened. Stairs and staircases should be kept clean, and the walls and ceilings whitewashed annually. Painted surfaces require re-painting every three years, and regular cleansing in the intervals. Where there are privies, they should be placed in the yards, and built and managed according to the regulations of the Local Government Board. Fixed dust-bins are an abomination, and refuse should be removed daily; but if ashpits be present, they should, like privies, be outside the block. See Burgh Police (Scotland) Act, pp. 605, 613.

COW-SHEDS.

Approaches and Surroundings.—The access should be free, well paved, and drained. Any adjoining yard must also be drained, and, if not paved, should be kept level and in good repair. The surrounding walls should be whitewashed, and on their inner sides may be tarred up to a certain height, usually 6 ft. above the ground-level. A water tap and hose should be provided for cleansing the yard, and all drains must be trapped. The boiler for boiling food for the cattle should not be near the cow-shed, and the midden should also be at a considerable distance, be provided with a concrete base raised a few inches from the ground, be flanked by stone supports, and be properly covered by a roof from which rain is led off by pipes. It is well to have a special gully and trapped drain provided for the manure heap. The cow-shed itself should not be closer to any human habitation than 100 ft. It should have an impervious floor of concrete or granite setts in concrete, the floors of the stalls sloping gently and being drained by channels towards a central gutter which should have a fall towards, and open into, a grated and trapped drain situated outside one end of the building. The stall divisions, and the walls, for about 6 ft. up, should be of impervious material, and may be coated with tar or asphalt. The roof should be kept in good repair, and may be supplied with ventilating openings on the ridge or other system. The upper part of one of the long walls may also be made to aid ventilation by being constructed of louvred boards. There must be windows, either in the roof or walls. The Royal Commission on Tuberculosis recommended a minimum of 600 to 800 cubic ft. of air space per cow, but the new regulations of the Local Government Board have definitely fixed the minimum space at 800 cubic ft. for constantly occupied sheds, and 1000 cubic ft. is not too much. A floor space of 50 square ft. per cow is required. A water supply must be laid on inside the cow-shed, and artificial heating provided for the winter months. For regulations of the Local Government Board, see p. 548.

SLAUGHTER-HOUSES.

The proper arrangement and construction of slaughter-houses can be gathered from what has been said regarding them under the consideration of offensive trades (p. 292), and what is elsewhere stated in connection with model by-laws and Sanitary Acts relating to abattoirs (p. 533). All that need be here noted is that, if a public abattoir is to become popular amongst the fraternity of butchers, it is advisable to provide private, as well as public, booths for slaughtering purposes.

VITAL STATISTICS.

POPULATION.

"VITAL STATISTICS" is the science of numbers, expressive of the facts relating to the public health of communities. A knowledge of this science is essential to the medical officer of health if he is to be able to render the numerical returns of his district, so that they may be of use for amalgamation or comparison with those of other districts. All vital statistics are based upon population, and the population is ascertained for this purpose in the following ways:—

1. Enumeration in census years.
2. Estimation in intercensal years.

I. ENUMERATION OF THE POPULATION.

This is accomplished at regular intervals by means of a census, and by this means alone is the actual population known. In the United Kingdom the census is taken decennially at the end of the first quarter of the year, the last census being in 1901. The science of vital statistics would be more accurate than it is if the census were quinquennial, instead of decennial. This would allow less deviation between the actual and the estimated number of the population in the intervening years. Variations in the rate of increase or decrease of population would be disclosed at more frequent intervals, and figures, such as birth and death rates, would be more accurate. Any overestimate of the population causes a death-rate to appear lower than it really is, and to give a false impression of the salubrity of the district. In London a modified quinquennial census is taken, and it would be very desirable that in 1906 this should be extended in full detail and applied to the whole country. Further, were it not for the holiday migration, which causes some dislocation of the population in the centre of the year, there would be an advantage in having the census taken at the end of the first half of the year, instead of at the end of the first quarter.

The reason for this is, that rates, such as birth and death rates, are all calculated on population as estimated at the middle of the year, or, as it is called, the *mean population.*

At present, even in census years, the enumerated population requires correction for the three months between the census and the centre of the year, in order to obtain the true mean population of the census year.

CENSUS.—The information required of each householder embraces the following details as to each person who slept or abode in the house on the census night:—

(1) Name. (2) Age in years completed at last birthday. The age of children under two years must be stated in months. (3) Sex. (4) Occupation. (5) Birthplace, or, if a foreigner, the nationality. (6) Relationship to the head of the house. (7) Civil relation, *e.g.* married, single, widower, or widow. (8) Infirmities, *e.g.* if deaf and dumb, blind, or insane. (9) The number of rooms and of their occupants in the case of tenements with less than five rooms. (10) Whether employer, employed, or working on own account without subordinates. (11) Language, *e.g.*, in Scotland, Ireland, and Wales as to Gaelic-, Erse-, and Welsh-speaking individuals.

The census report shows the age and sex distribution of the population of the whole country, and of each district having a separate sanitary authority.

The most accurate census is not free from errors connected with age, infirmity, and occupation.

(*a*) *Age.*—Adults are apt, perhaps from ignorance, to state their age in round numbers, *e.g.* 40 or 50, and this results in grouping of the population round multiples of 10, so that, in calculating rates at particular ages, it becomes advisable to use the decennia, *e.g.* 35–45, 45–55, instead of 30–40 and 40–50. Deliberate mis-statement of age also vitiates the figures, *e.g.* women aged 20–25 are often found to exceed in number the girls aged 10–15 enumerated ten years earlier.

Very old people have a tendency to overstate their age, whilst the ages given for young children are sometimes incorrect, owing to parents using vaguely the terms, "1 year old" and "2 years old."

(*b*) *Infirmity.*—Errors arise owing to a reluctance to acknowledge infirmity, and to the absence of strict definition of the amount of infirmity requisite to necessitate entry in the return.

(*c*) *Occupations.*—Confusion is apt to arise owing to the occupations being stated in too general terms, leaving the exact employment doubtful.

The distinction between employer and employed may not be well defined; thus, "joiner" may mean a working joiner or the master who employs working joiners and superintends them, but who himself does no manual work.

II. ESTIMATION OF POPULATION.

This is requisite in order to ascertain the mean population, or population at the centre of each year.

There are three methods of estimation in common use, their bases respectively being the rate of increase of the population, the number of inhabited houses, and the birth-rate.

(A) *Rate of Increase of the Population.*—If we assume that the population is increasing at the same rate of increase which took place in the years intervening between the two last census years, it is a simple calculation to obtain an estimate of the number to which that population has now attained. The essential point, and this requires to be clearly grasped, is that the increase is progressive not merely in arithmetical (*e.g.* 1, 2, 3, 4, 5, 6), but in geometrical (*e.g.* 1, 2, 4, 8, 16, 32) progression. The increase accumulates by compound interest, and not merely by simple interest. The annual increase is not constant, but is larger each successive year.

If we denote by r the annual rate of increase per unit of the population, then a population of 1 will at the end of a year become $1 + r$, and at the end of another year this population of $1 + r$ will not be $1 + 2r$, but will be $(1 + r)^2$, and at the end of n years the population of 1 will have amounted to $(1 + r)^n$.

If the number of the population be denoted by P, then in n years P will have increased to $P(1 + r)^n$.

To find r, the aid of logarithms is of service; and before proceeding to the calculation, it may be well to briefly explain their nature and advantages.

Logarithms are auxiliary numbers of such a character that—(1) multiplication of common numbers is performed by the addition of their logarithms; (2) division of common numbers is performed by subtraction of their logarithms; (3) involution, or the raising of a common number to any power, is performed by multiplying its logarithms by the power to which the number is to be raised; (4) evolution, or the extraction of the roots of a common number, is performed by dividing its logarithms by the number (exponent) of the root required.

In each case there is thus obtained the logarithm of the number required to be found, and from a table of logarithms this number is at once obtained.

These auxiliary numbers or logarithms are the powers to which a fixed number, called *the base*, must be raised in order to produce the number of which the auxiliary number is the logarithm. The usual and most convenient base is 10, and with this base the logarithm of 2 is ·30103, because—

$10^{\cdot 30103} = 2$, *i.e.* 10 raised to the ·30103 power yields 2 as product.

It is obvious that the logarithm of 10 will therefore be 1, and that of 100 will be 2, since $10^2 = 100$.

Returning now to the method of finding the rate of increase of population—

Let P^1 = population as enumerated at the last census.

P = " " " previous census.

r = net annual rate of increase per unit of the population, *i.e.* the rate of increase per unit when all the factors which in any way affect such increase have been taken into account.

Then $P^1 = P(1 + r)^{10}$, since 10 years have elapsed between the census years. Taking the logarithms of both sides of this equation, it becomes—

$$\text{Log } P^1 = \log P + 10 \log (1 + r), \text{ or}$$
$$\text{Log } P^1 - \log P = 10 \log (1 + r), \text{ or}$$
$$\frac{\text{Log } P^1 - \log P}{10} = \log (1 + r).$$

From a table of logarithms the value of $(1 + r)$ is determined, and so the value of r is easily found.

Example.—If the population of England and Wales in 1891 was 29,002,525, and in 1901 had increased to 32,525,716, what was the annual rate of increase per unit of the population?

$$\text{Log } 32{,}525{,}716 = \log 29{,}002{,}525 + 10 \log (1 + r).$$
$$\text{Log } 32{,}525{,}716 - \log 29{,}002{,}525 = 10 \log (1 + r).$$
$$7{\cdot}5122269 - 7{\cdot}4624357 = 10 \log (1 + r).$$
$$\cdot 0497912 = 10 \log (1 + r).$$
$$\cdot 00497912 = \log (1 + r).$$
$$1{\cdot}0115 = 1 + r.$$
$$\cdot 0115 = r.$$

Having ascertained r, or the annual rate of increase per unit, it is possible to calculate the number to which the population P^1 will have increased at any period after the last census. The assumption is made that the rate of increase is the same as in the previous 10 years. Suppose that it is required to know the population to which P^1 has increased at n years after the last census, then—

$$\text{Log } P^1 + n \log (1 + r) = \text{log of the population required.}$$

In such calculations the population required is usually the *mean population*, or population at the centre of the year; whereas the census population, from which the calculation is made, is population at the end of the first quarter of the census year. Allowance must in this case be made for the additional quarter's increase, and this may be done by adding the fraction $\frac{1}{4}$ to n. If n be 3 years, and it be required to know the mean population 3 years after a census, the equation would be—

$$\text{Log } P^1 + 3\tfrac{1}{4} \log (1 + r) = \text{log mean population 3 years after the census,}$$

or the logarithm of the mean population required is equal to the logarithm of the last census population + three times the logarithm of the annual increase + one-fourth of the logarithm of the annual increase.

Example.—The population of Scotland being at the census of 1891, 4,025,647, and at the census of 1901, 4,472,000, find the mean population in 1904.

$$\text{Log M.P. } 1904 = \log 4{,}472{,}000 + 3\tfrac{1}{4} \log (1 + r), \text{ and}$$

$$\text{Log } (1 + r) = \frac{\log 4{,}472{,}000 - \log 4{,}025{,}647}{10} = \cdot 0045666.$$

$$\begin{aligned} \text{Log M.P. } 1904 &= \log 4{,}472{,}000 = 6\cdot 6505018 \\ &+ 3 \log (1 + r) \quad = 0\cdot 0136998 \\ &+ \tfrac{1}{4} \log (1 + r) \quad = 0\cdot 0011415 \\ \text{,, } \quad \text{,, } &= \qquad\qquad\quad \underline{6\cdot 6653431.} \end{aligned}$$

Mean population 1904 = 4,627,465.

This method of estimation of the population is the most accurate, but is liable to error if the rate of increase of the population does not remain constant. The best remedy would be more frequent enumerations of the population.

(B) *Inhabited Houses.*—This method consists in ascertaining the number of houses inhabited by the population, as stated in the assessment books of the year, and then multiplying this number by the average number of inhabitants per house as revealed by the last census. The population thus estimated is often fairly accurate, but the result may be vitiated by any considerable alteration in the class of houses occupied, involving change in the average number of their occupants.

(C) *Birth-rate.*—Assuming that the birth-rate per 1000 of the population remains constant, and if the number of births in any year is known, the population can be calculated thus—

$$\frac{\text{Number of births in the year} \times 1000}{\text{Birth-rate per 1000 in last census year}} = \text{Population.}$$

Example.—If 9750 births occur in a city, in which the birth-rate at last census was 30 per 1000, its estimated population is—

$$\frac{9750 \times 1000}{30} = 325{,}000.$$

This method is apt to be inaccurate owing to the birth-rate being inconstant, and, in fact, in recent years this rate has steadily declined.

A further error in this method is that it takes no account of alterations of population due to migration.

Increase and Decrease of Population.—Actual increase of population depends on—(1) natural increase; (2) migration.

1. *The natural increase of population* is the excess of births over deaths. This excess declined in England in 1881–91, as compared with 1871–81.

Such decline might be due to—(*a*) lowered birth-rate, or (*b*) increased death-rate. In this case it was due to the former. The natural increase of population may exceed the actual increase if emigration exceed immigration.

The natural increase of population varies very much in different countries, and a comparison may be instituted between them as to the number of years in which their respective populations would double themselves by natural increase; whereas Prussia and England would do so in 49·2 and 59·1 years respectively, the corresponding figure for France is 591 years.

2. *Migration.*—The effects of migration on population of late years have been manifested in the tendency of the rural population to enter town life, so that relatively a large proportion of the population now resides in urban districts. This is due to the greater attractions of town life, the limited amount of land available for agriculture, the increase in manufacturing industries and the higher wages associated with them.

The depopulation of rural districts is not actual, but only relative, the rate of increase of their population being much less than that of towns.

Migration of young adults from the country into the towns tends to alter the age constitution of town populations, and this, as we shall see later, has an important bearing on their comparative healthiness, as disclosed in their death-rates.

The census report as to the birthplaces of individuals serves to show the amount of internal migration between the different countries of the United Kingdom, and the extent of immigration of foreigners. Emigration per 1000 of the population is greatest in Norway, the United Kingdom, and Sweden, and is lowest in France.

Natural increase and immigration have combined to raise enormously the population of the United States of America.

Conditions favouring actual increase of population are—

1. High birth-rate 2. Low death-rate	Natural increase.	3. Little emigration 4. Much immigration	Migration.

Conditions favouring actual decrease of population are—

1. Low birth-rate 2. High death-rate	Natural increase.	3. Much emigration 4. Little immigration	Migration.

Age and sex constitution of the population.—The influence of the age and sex distribution on rates, *e.g.* death-rates, will be discussed in connection with such rates. The proportions in which the population is divided between the sexes and at different groups of ages varies in different countries.

It is interesting to compare, as in the following table, the differences in age constitution in the component parts of the United Kingdom and in certain other countries:—

AGE CONSTITUTION OF POPULATIONS (1891).

Ages.	England and Wales.	Scotland.	Ireland.	United Kingdom.	Australia.	United States.	Hungary.	France.	Average of these and nine other Countries.
Under 10 .	239	243	208	236	265	243	262	175	238
10–20 . .	213	216	234	216	208	217	191	174	202
20–30 . .	172	168	162	170	197	183	156	163	161
30–40 . .	131	126	108	128	132	135	137	138	129
40–50 . .	99	96	98	100	85	94	108	123	104
50–60 . .	71	72	85	72	64	64	78	101	79
60–70 . .	47	48	60	48	33	39	46	76	54
Over 70 .	28	31	45	30	16	25	22	50	33
	1000	1000	1000	1000	1000	1000	1000	1000	1000

This table shows the relative diminution of young people under 20, and the excessive proportion of those at older ages in the population of France. In Ireland also there is too great a proportion at the higher ages, but the causes at work in the two countries are very dissimilar. The low birth-rate is common to both countries, but owes its origin to different causes ; and emigration, which powerfully affects the Irish population, is practically inoperative in France.

Comparing the age constitution of the United Kingdom in 1891 with that of 1881, the ratio (*a*) of young people under 15 has fallen, especially in Ireland ; (*b*) of people aged 15–45 has risen, especially in England and Ireland ; (*c*) of people aged 45–55 has risen in England and Ireland, and fallen in Scotland ; (*d*) of people over 55 has declined in England, and risen in Scotland and Ireland.

The sex constitution of population shows in general an excess of females. and this has risen on the average about 3 per 1000 between 1881 and 1891. The average proportion of females to 1000 males is 1015, but is higher in many places ; thus in 1891 the proportion was in the United Kingdom 1060, England 1064, Scotland 1072, Ireland 1029, Australia 866, United States of America 953, Hungary 1015, France 1014.

The preponderance of females has increased in England and the United Kingdom as a whole, but somewhat declined in Scotland and Ireland.

The following table shows the age and sex constitution of the population of the United Kingdom in 1891, the figures for 1901 not being yet available :—

AGE AND SEX CONSTITUTION OF UNITED KINGDOM.

Ages.	Males.	Females.	Total.	Ratio.	Females to 1000 Males.
Under 10 . .	4,455,000	4,453,000	8,908,000	236	1000
10–20 . . .	4,073,000	4,071,000	8,144,000	216	1000
20–30 . . .	3,052,000	3,383,000	6,435,000	170	1109
30–40 . . .	2,329,000	2,496,000	4,825,000	128	1072
40–50 . . .	1,785,000	1,950,000	3,735,000	100	1092
50–60 . . .	1,286,000	1,444,000	2,730,000	72	1123
60–70 . . .	836,000	982,000	1,818,000	48	1174
Over 70 . .	499,000	640,000	1,139,000	30	1300
Totals . .	18,315,000	19,419,000	37,734,000	1000	(1060)

The proportions in which the population of England and Wales is distributed between the two sexes, and at eleven groups of ages, is conveniently shown by taking one million, and dividing it up according to the proportions found to have existed in a specified period.

This is then termed the *standard million*, since it forms a standard with which the populations of other places can be compared.

The standard million, as divided according to the proportions existing in the years 1881–90, is shown in this table :—

STANDARD MILLION.

FROM SUPPLEMENT TO THE FIFTY-FIFTH ANNUAL REPORT OF THE REGISTRAR-GENERAL.

Age.	Males.	Females.	Persons.
0	64,122	64,557	128,679
5	59,333	59,673	119,006
10	54,806	54,765	109,571
15	49,720	50,287	101,007
20	42,922	47,564	90,486
25	71,131	77,499	148,630
35	55,095	58,944	114,039
45	40,472	44,478	84,950
55	27,151	30,893	58,044
65	15,184	18,326	33,510
75 and upwards . . .	5,591	7,487	13,078
All ages . .	485,527	514,473	1,000,000

BIRTHS.

Registration ; Still-births ; Birth-rate ; Illegitimate Births ; Proportion of Sexes at Birth.

Registration.—Every birth in this country must be registered within forty-two days, and the register signed by (1) the father or mother of the child ; or, in default thereof, by (2) the occupier of the house in which the birth took place ; or (3) by each person "present at the birth" ; or (4) by the person in charge of the child.

There are two chief defects in the registration of births in this country, namely, the age of the parents at the birth of each child is not recorded, and the order of birth is not given.

The birth must be registered at the registrar's office, or, on payment of a fee of one shilling, the registrar will attend at a private house to register a birth.

It is believed that the number of unregistered births is few, those that evade registration being most probably illegitimate.

Still-births.—These are not registered either as births or deaths, but undoubtedly ought to be recorded. Their number is estimated at 3 to 4 per cent. of total births, the proportion among illegitimate births being somewhat higher, *i.e.* 4 to 6 per cent. More males are still-born than females, and still-birth is more common among male illegitimate than male legitimate children. More still-births occur in the spring months than at other periods of the year. Statistics of still-births not being available in this country, those of other countries are the source of the above information. Further reference to this subject will be found on pp. 427 and 428.

Birth-rate.—The birth-rate, or crude birth-rate, is the number of births which occur annually per 1000 of the mean population living at all ages.

It serves as a fair test of the fecundity of the same community in a series of years, but is not available for comparison between separate populations, unless their age and sex composition be alike.

This is, however, the rate recorded in official returns. A better method is to state the birth-rate as the number of annual births per 1000 women living at child-bearing ages (15 to 45), but even this does not afford means for accurate comparison between localities and communities whose social and industrial conditions are dissimilar.

The accurate method of stating the birth-rate is to separate the legitimate and illegitimate births, expressing the former as an annual rate per 1000 married women of child-bearing ages, and the latter as an annual rate per 1000 women of child-bearing ages not living in the conjugal state, *i.e.* unmarried women, widows, and divorcées.

The birth-rate has in recent years steadily declined not only in this country, but in all civilised countries. In England it reached its maximum in 1876 at 36·3, but in 1896 and 1897 was only 29·7. The rate in Scotland in 1900 was 30·4 per 1000. The chief causes of this decline are the postponement of marriage to later ages in life, the increase of celibacy shown by the decrease in the marriage-rate, and the diminished fecundity of marriages due to intentional avoidance of child-bearing. The birth-rate is higher in urban than in rural populations, owing to the higher marriage-rate of the former, and the fact that they possess a larger proportion of women at child-bearing ages who marry somewhat earlier in life. Another factor is found in the higher infantile mortality in towns, which tends to lessen the intervals of child-bearing by interference with the period of suckling.

The birth-rate is lowest—(1) in agricultural districts; (2) in some countries, such as France; (3) during war; and (4) at the end of the year. It is highest—(1) in mining and industrial districts; (2) in towns; (3) among certain nationalities, *e.g.* Hungary; (4) in times of national prosperity; (5) in the earlier half of the year; (6) possibly among the poor as contrasted with the rich.

In estimating the healthiness or otherwise of any district, the birth-rate should be considered as well as the mortality.

Illegitimate Births.—The proper method of stating the illegitimate birth-rate has been recorded above, but this rate is frequently given either as a rate per 1000 of the population living at all ages, or as a proportion of the total births. The custom of stating the illegitimate births as a percentage of the total births is erroneous, since the same number of illegitimate births would appear as a higher or lower proportion, according as the number of legitimate births fell or rose. The error is termed that of two variable factors. The illegitimate birth-rate has declined in recent years proportionally even more than the legitimate birth-rate, and it is lower in this country than in continental countries. In Edinburgh, during 1900, the illegitimate births formed 7·8 per cent. of the total births, but only 1·18 per cent. of the possible mothers. The latter figure is calculated on the estimated number of unmarried women and widows between 15 and 45 years of age. A comparison with similar figures for Leith for the same year illustrates the advantages of the latter method of stating the illegitimate birth-rate. The illegitimate births in Leith in 1900 formed 4·4 per cent. of the total births, but the percentage to possible mothers was 1·24.

Proportion of the Sexes at Birth.—As a rule, more males are born than females. For every 1000 females born in England and Wales in 1891–95, there were born 1036 males. This proportional excess of males has fallen from 1050, the figure in 1848, and is now smaller than in any other European country. In some places, 1080 males to 1000 females is the proportion. The proportion of males is greater in large than in small families, and in the earlier-born rather than the later-born members of a family.

In Scotland in 1900 the proportion of males born to 1000 females was 1047.

MARRIAGE.

Registration; Marriage-rate; Remarriages; Mean Age at Marriage; Fecundity of Marriages; Natality.

Registration.—Marriages, like births and deaths, must be registered within a specified period.

Marriage-rate.—The marriage-rate is the annual number of marriages per 1000 of the mean population living at all ages, but it should be stated per 1000 of the unmarried persons living at marriageable ages. When calculated in the latter way, the rate is found to be highest in Hungary, and lowest in Ireland. The marriage-rate serves to indicate to some extent the national prosperity, rising with abundance, and falling in hard times. It has been noticed that the English marriage-rate frequently, but not invariably, oscillates in the same direction as the value of export or import trade and the average price of wheat in the United Kingdom. The marriage-rate falls during war, rising again on the recurrence of peace. The marriage-rate is higher in large towns than in rural districts, and is lowered by the increased standard of comfort causing postponement of marriages. The marriage-rate has tended to decline of late years in France, Germany, and England, and in the last-named has fallen from 17·6 (in 1876) to 15 per 1000 of the population. The rate for 1900 in Scotland was 7·5 per 1000, and in Ireland only 4·8. Notwithstanding the decline in the marriage-rate, the proportion of married persons in the whole population has not similarly decreased, for though the lower marriage-rate diminishes the number of married persons in the population, it also diminishes the unmarried by lowering the birth-rate.

Remarriages.—Of the males who marry, 10 per cent. are widowers; and of the females, 7 per cent. are widows. The proportion of widowed persons who remarry has steadily diminished.

Mean Age at Marriage.—The mean age at marriage in both sexes is still rising, and it can be readily understood that the higher age of the female at marriage tends to diminish the birth-rate and to increase the interval between successive generations. The mean age at marriage is higher among the professional and independent classes of society than among the working-classes.

Fecundity of Marriage.—This is dependent on two factors—(*a*) the duration of married life; and (*b*) the age at marriage, more especially of the female, since her reproductive period is shorter than that of man. The average number of births to a marriage is in Britain about 4·5, but is higher among the younger wives calculated alone.

Natality.—The probability of a birth occurring within a year can be calculated for all possible combinations of ages of the parents, and the age of maximum fecundity in each sex can be ascertained. Unfortunately the requisite data are not yet available for this country; but tables of natality have been prepared by Körösi in Buda-Pesth, and these show monosexually and bisexually the probability of a birth at the age of each parent individually, and for certain combinations of ages of parents.

Lines analogous to isobars and isotherms can be drawn through combinations of ages having the same probability: such lines are called isogenes.

DEATHS.

Registration; Certification; Still-births; Inquests; Causes of Death; Death-rate.

Registration.—Every death must be registered within five days, on personal information to the registrar by the nearest relatives of the deceased present at the death, or in attendance during the last illness. The registrar may register a death either on the statement of such qualified informant, or on a certificate of a verdict of a coroner's jury. The registrar issues a certificate to the qualified informant as an authority for burial. Registration of a death is not compulsory before burial can take place, but any person burying the deceased without a coroner's order or a registrar's certificate must notify the registrar within seven days. A registrar aware of a non-registered death may, after fourteen days and within twelve months, summon a qualified informant to give information. After twelve months, a death is only registrable by the registrar on the authority of the Registrar-General. On payment of a fee of one shilling, the registrar will attend at a private house to register a death.

Certification.—A medical certificate of the cause of death must be given to the qualified informant, unless refused on reasonable grounds. The form of death-certificate is prescribed, and whenever child-birth has occurred within one month before death, the fact should be entered in the certificate as well as the cause of death. After an inquest, the coroner is bound to give a certificate as to the cause of death, and transmit it to the registrar within five days. The verdict of the jury supersedes any previous medical certificate as to the cause of death. There is much need for reform in the law regarding the certification and registration of deaths, and especially is this the case in connection with still-births which are not, and uncertified deaths which are, at present registered. The whole subject of death certification has been considered by a Committee of the House of Commons, and the following recommendations were made, but so far these have not been rendered compulsory; they serve to indicate the directions in which reform is necessary:—

(1) No death to be registered without medical, coroner's, or fiscal's certificate. (2) Appointment of a medical certifier for each sanitary district to deal with uncertified deaths. (3) Personal inspection of the dead body by the attendant practitioner to be compulsory before certification, or, in default of such inspection, a supplementary certificate to be required from two neighbours of the deceased verifying the fact of death. (4) Medical practitioners to send death certificates direct to the registrar, and not to the relatives of the deceased.

(5) The form of death certificate to be obligatory and prescribed. (6) That it should be a penal offence to bury or dispose of a body, except in epidemic times, without a registrar's order stating the place and mode of disposal. This order, after fulfilment, to be returned to the registrar who issued it. (7) No dead body to be kept beyond eight days without permission of a magistrate. (8) Burial in pits or common graves to be discontinued. (9) Still-births of seven months and upwards to be registered upon the certificate of a registered medical man. Burial or other disposal of still-birth not to be permitted without an order from the registrar. (10) Subject to the approval of the Crown Office, precognitions by procurators-fiscal in Scotland to be communicated to the representatives of the deceased if applied for.

Proportion of deaths certified.—Of total deaths, 91·5 per cent. are certified by doctors, 6 per cent. by coroners after inquest, and 2·5 per cent. are uncertified.

Still-births.—At present, burial of a still-birth is allowed on—(1) certificate of still-birth from a medical practitioner; (2) declaration of a qualified informant, *i.e.* person present at the birth, or the parent of the child; (3) coroner's order after inquest.

The absence of compulsory registration of still-births before burial is a serious danger to the life of feeble infants, who may be buried as still-births. Our knowledge of the proportion of still-births to total births is derived from the statistics of such countries as Germany, France, and Japan, in which the figures are respectively 33, 50, and 95 per 1000.

Inquests.—It is the duty of the registrar to report to the coroner all deaths, whether medically certified or not, which are—(1) due to direct or indirect violence; (2) attended by suspicious circumstances; (3) sudden; (4) due to a cause unknown; (5) those of children respecting whom notice must be given to the local authority under the Infant Life Protection Act. The coroner decides in which cases among the first four groups an inquest is necessary; in the fifth group, the law requires that an inquest be held, unless there is a satisfactory medical certificate of the cause of death.

Causes of Death.—The registered causes of death are not absolutely accurate. Errors arise from the fact that 4·5 per cent. of total deaths are attributed to ill-defined and non-specified causes. Inaccuracy may also follow from want of uniformity in the nomenclature of disease, and from errors of diagnosis or deliberate omissions.

Classification of the causes of death.—The Registrar-General classifies the cause of death in eight groups—(1) *Zymotic diseases*, including febrile, specific, epizootic, and septic diseases; (2) *parasitic*; (3) *dietetic, e.g.* scurvy and alcoholism; (4) *constitutional, e.g.* tubercle; (5) *developmental, e.g.* congenital diseases and old age; (6) *Local, e.g.* diseases of the various systems; (7) *violence, e.g.* suicide, accident, homicide, execution; (8) *ill-developed and non-specified causes.*

Death-rate.—The ratio between deaths and population may be stated either as so many deaths per annum per 1000 of the population, or as one death to so many people; the former is the more usual method.

The death-rate is sometimes called the rate of mortality, but it is better to avoid this term, as it has another meaning in actuarial work (see p. 462).

The General or Crude Death-rate, then, is the number of deaths per annum from all causes per 1000 of the mean population living at all ages;

e.g., if the deaths from all causes in a year $= 500$, and the mean population out of which these deaths occurred $= 25{,}000$, the death-rate $= \frac{500 \times 1000}{25{,}000} = 20$.

This is one death to every 50 people, *i.e.* $\frac{25{,}000}{500} = 50$. The death-rate per annum, or, shortly, the death-rate, may, however, be calculated each week or month from the number of deaths occurring in the week or month, and it is then assumed that the same number of deaths will occur each week or month for a year. The calculation is usually done by taking, instead of the whole population, only such proportion of it as corresponds to the period in which the deaths have occurred. Suppose this to be one week; then the weekly population is obtained by dividing the mean population of the year by the number of weeks in the year, namely, 52·17747, and the weekly population $= \frac{\text{mean population}}{52{\cdot}17747}$.

The death-rate is then obtained thus—

$$\frac{\text{Number of deaths in a week} \times 1000}{\text{Weekly population}} = \text{Death-rate.}$$

An advantage of this method is, that the number of the weekly population, when once calculated, is known for a whole year, and this saves a longer calculation each week, which would be necessary if the death-rate were calculated thus—

$$\frac{(\text{Number of deaths in a week} \times 52{\cdot}17747) \times 1000}{\text{Mean population}} = \text{Death-rate.}$$

Similarly, the death-rate is calculated from the deaths occurring in a month—

$$\frac{\text{Number of deaths in a month} \times 1000}{\text{Monthly population}} = \text{Death-rate.}$$

Since a year contains 11·8 months of 31 days each, the monthly population $= \frac{\text{Mean population}}{11{\cdot}8}$.

If the month be one containing less than 31 days, calculate by simple proportion the number of deaths that would have occurred in it had it had 31 days, *e.g.*, if the deaths in February (28 days) were 42, and the mean population of the year was 27,435, the death-rate is found thus—

$$28 : 31 :: 42, \quad \frac{31 \times 42}{28} = 46{\cdot}5 = \text{deaths that would have occurred in 31 days.}$$

$$\frac{27{,}435}{11{\cdot}8} = 2325 = \text{monthly population.}$$

$$\text{Then } \frac{46{\cdot}5 \times 1000}{2325} = \text{Death-rate.}$$

It is important to remember that the death-rate thus ascertained is an annual death-rate calculated from the deaths occurring in shorter periods. This crude death-rate of any town or district is of value in comparing the mortality of that town or district at different periods, if there has been no marked change in the character of its population and industries. It is of no value whatever in comparing the healthiness or otherwise of that district with any other district. This is due to the influence exerted upon the death-rate by the following factors, which are seldom exactly the same in any two districts, namely, the age and sex distribution of the population, migration, birth-rate, public institutions, and industrial conditions. We shall first detail briefly the influence of each of these factors on the death-rate, and then show how the crude death-rates of different populations may be so corrected as to yield rates by which different populations may be strictly comparable.

Public Institutions.—Many towns and districts possess large infirmaries and other institutions, such as asylums and workhouses, whose inmates are derived from outside the boundaries of the town or district. The deaths of such inmates would, if all included in the calculation, tend to raise the death-rate unduly, and such deaths should be allocated to their respective districts. On the other hand, the deaths of inhabitants of the district who may have died in outlying institutions must be included, or the death-rate will appear lower than it really is.

Migration. — The interchange of sick persons between the town and country districts, *e.g.* the reception of sick from the country into urban hospitals and the emigration from towns into the country of phthisical and aged people, may affect the death-rate to some extent. The main effect of migration on the death-rate is, however, due to the immigration of young and healthy persons from the rural districts into the manufacturing towns, thus altering the age and sex distribution of the population, and providing, in towns, a population favourable in these respects to a low death-rate.

In residential towns a similar effect is produced by the large numbers of domestic servants attracted to them.

Industrial Conditions.—In general, it may be stated that the tendency of industrial conditions is to increase the death-rate of a district; an effect modified, however, by the influx of young and strong adults attracted to share in the higher wages obtainable in industrial centres. The influence of special trades will be considered in more detail later.

Birth-rate.—The birth-rate only affects the death-rate in so far as it changes the age constitution of the population. A high birth-rate may at first increase the death-rate, owing to the large numbers of deaths of infants and young children, but if a high birth-rate be continued for longer than five years, it tends more and more to lower the death-rate, owing to the increasing numbers of the population who are living at ages at which death is a comparatively rare event. A temporary high birth-rate, then, increases the death-rate; a continued high birth-rate lowers the death-rate. A low birth-rate may coincide with a low death-rate; but, on the other hand, a continued low birth-rate, owing to the increase in the average age of the population, may be accompanied by a high death-rate.

So a high birth-rate for one decade, followed by a low birth-rate in the succeeding decade, is a combination producing a low death-rate.

Age and Sex Distribution.—*Age.*—The age distribution of the population has a notable effect on the general death-rate. The death-rate at ages under 5 and over 55 is higher than the death-rate at all ages, and much higher than the death-rate at ages between 5 and 55. The larger the proportion of young adults in the population, the more favourable is its age constitution to a low death-rate, and this condition is fulfilled in newly-settled communities, in towns, and in manufacturing districts.

Sex.—The death-rate of females at all ages is lower than that of males at all ages. Not only is this true of the sexes as a whole, but at each group of ages, with very slight exceptions, the same fact holds good. So an excess of females in a population conduces to a low death-rate.

The influence on the general death-rate of a district exerted by the age constitution of its inhabitants is much more important than that exerted by sex distribution.

Varieties of Death-rate.—Death-rates may be crude, recorded, standard, corrected, and special.

The crude death-rate has been already explained.

The recorded death-rate is the death-rate calculated in the same way as the crude, but with allowance made for the deaths of inmates of public institutions. To the number of deaths registered in the district add the deaths of inhabitants of the district who have died in outlying institutions, and from the total deduct the deaths of inmates of internal institutions whose residence is outside the district. This will give the number of deaths to be used in the calculation. To ascertain the population out of which these deaths occurred, it is necessary to make allowance for the population in the internal institutions, but derived from outside the district, and to deduct it from the mean population. It is not generally possible to know the number of inhabitants who are in outlying institutions with temporary illness; if known, this number should be added to the mean population. An illustrative example will make this calculation plain:—District A possessed a mean population of 43,000, and there occurred in it in a year 817 deaths, of which 120 took place in its public institutions, the population of which is derived from outside district A, and, as revealed by last census, amounted to 2000. There were 41 inhabitants of district A who died during the year in institutions in district B. The average number of inhabitants of district A who are in institutions in district B is unknown. Find the recorded death-rate of district A and compare it with the crude death-rate—

Recorded death-rate.—Deaths, $817 + 41 - 120 = 738$. Mean population, $43{,}000 - 2000 = 41{,}000$.

$$\frac{738 \times 1000}{41{,}000} = 18 = \text{Recorded death-rate.}$$

Crude death-rate.—This is $\frac{817 \times 1000}{43{,}000} = 19$.

So that district A would, if such allowances were not made, appear to possess a higher death-rate than it really has.

Standard death-rates.—The standard death-rate of a country, *e.g.* England and Wales, is the average death-rate at all ages experienced during the previous intercensal decade. Thus it is based upon the data of a decennium, and not, like the rates previously considered, on annual, monthly, or weekly data.

The standard death-rate of a town, district, or any part of a country, is the death-rate at all ages which would have occurred in it if each age- and sex-group of its population had experienced the same death-rate as occurred in the corresponding age- and sex-group in the whole country during the previous intercensal decade.

The standard death-rate of a portion of the country will be the same as that of the whole country, only if its population is distributed as to age and sex in the same proportions as that of the country as a whole.

To calculate the standard death-rate, *e.g.* of a town, obtain from the census report the number of males and females living respectively in each age-group. Begin with the males in the age-group 0–5 years, divide by 1000, and multiply by the mean annual death-rate experienced in the whole country during the previous intercensal decade per 1000 males aged 0–5. This gives the number of deaths that would have occurred in this group. Similarly, calculate the deaths for each sex- and age-group. Add together the numbers of deaths thus calculated.

Then the $\frac{\text{Total calculated deaths} \times 1000}{\text{Population}}$ = Standard death-rate for that town.

The standard death-rate of a town having been ascertained, the figure holds good for the 10 intercensal years, and provides the means of correcting the annual death-rates for these 10 years.

Comparison of the standard death-rates of different towns serves to show how far the age and sex distribution of their respective populations is favourable or otherwise to a low death-rate, but prognosticates nothing as to their comparative healthiness.

Corrected Death-rates.—These are annual death-rates corrected as regards deaths in public institutions, and as regards age and sex distribution of the population, so that the corrected death-rates of different places can be fairly compared one with another. The corrected death-rate, *e.g.* of a town, is the death-rate which would have been recorded in the town if the age and sex distribution of its population had been the same as that of the country as a whole. The *corrected death-rate* is then the *recorded death-rate* multiplied by a *factor* of correction for age and sex distribution.

The factor for each place in England and Wales is thus obtained—

$$\frac{\text{Standard death-rate for England and Wales}}{\text{Standard death-rate for the place.}} = \text{Factor.}$$

So the standard death-rate of a place bears the same relation to the standard death-rate of England and Wales as the recorded death-rate of the place bears to the corrected death-rate of the place.

The following table gives the Standard, Recorded, and Corrected Death-rates, and the Factors for some typical towns and for the whole country: it also shows the Comparative Mortality Figure, which is now to be explained :—

Towns in the order of their Corrected Death-rates.	Standard Death-rate.	Factor for Correction for Sex and Age Distribution.	Recorded Death-rate, 1899.	Corrected Death-rate.	Comparative Mortality Figure, 1899.
Cols.	1	2	3	4	5
England and Wales . .	19·15	1·0000	18·33	18·33	1000
England and Wales less the thirty-three towns .	19·45	·9845	17·29	17·02	929
Thirty-three towns . .	17·71	1·0813	20·19	21·83	1191
Norwich	19·99	·9579	17·29	16·56	903
Bristol	18·45	1·0379	18·25	18·94	1033
London	17·97	1·0656	19·78	21·08	1150
Newcastle	17·58	1·0892	20·56	22·39	1221
Birmingham . . .	17·33	1·1050	20·84	23·03	1256
Sheffield	17·22	1·1120	22·16	24·64	1344
Manchester . . .	16·90	1·1331	24·61	27·89	1522
Liverpool	17·44	1·0980	26·38	28·97	1580

Comparative Mortality Figure.—Having obtained the corrected death-rates of different places, it is desirable to compare them, not only with each other, but with the mortality to which the whole country has been subjected in the same year. This is accomplished by means of the comparative mortality figure.

The recorded death-rate of England and Wales at all ages for the year is supposed to be 1000, and the corrected death-rates are compared with it.

The recorded death-rate of England and Wales for the year is to the corrected death-rate of the district for the year as 1000 is to the comparative mortality figure of the district for the year.

If the recorded death-rate of the country were 17·5, and the corrected death-rate of a town 18·2, the comparative mortality figure of that town would be 1040—for 17·5 : 18·2 : : 1000 : 1040.

By these means a series of comparative mortality figures is obtained which contrast district mortalities with each other and with the whole country during the same period.

Comparison of Districts.—The corrected death-rates, and therefore the comparative mortality figures of two districts, give a fair indication of their comparative healthiness. The only other method of comparison between their death-rates which would be accurate, would be the laborious one of comparing the number of deaths in each age- and sex-group in proportion to the population living in each age- and sex-group in the two districts.

The death-rate of towns is usually higher corrected than crude, whilst the reverse is true in rural districts. The reason is that the age constitution of the population of towns is more favourable to a low death-rate than that of the country as a whole. The high death-rates common in manufacturing towns exist in spite of favourable age constitution, and depend on other conditions.

Special death-rates.—The death-rates previously described have referred to the whole population and to deaths from all causes. Special death-rates are differential as to persons and to causes of death. Thus the death-rates of persons may discriminate as regards nation, race, age and sex, climate and season, social and marital conditions, density of population, occupations, etc.

The death-rates due to the different causes of death show the mortality caused by certain diseases, *e.g.* the zymotic diseases, collectively and individually, diseases of the various systems, cancer, phthisis, suicide, etc. "The zymotic death-rate" is the death-rate produced collectively by the seven chief zymotic diseases, namely, smallpox, measles, scarlet fever, diphtheria, whooping-cough, "fever" (including typhus, typhoid, and simple continued), and diarrhœa.

I. PERSONAL SPECIAL DEATH-RATES.

(*a*) *Nation and Race.*—The general death-rate in different European countries varied in 1891–95 from 16·9 in Sweden to 31·8 in Hungary, but as these figures are not corrected for age and sex distribution to any common standard, they are not strictly comparable, and the differences cannot be assumed to be due entirely to national or racial peculiarities. But the statistics of the Southern United States show that the death-rate is distinctly higher among the negro portion of the population than among the white inhabitants, and that the excess is greatest at ages under 15.

(*b*) *Age and Sex.*—The population being divided into twelve age-groups, the death-rate affecting each age-group can be calculated, provided that—(1) the population in each age-group, and (2) the number of deaths in each age-group are both known. The latter is obtained from the registrar's returns, but the former requires calculation, and is estimated on the assumption that the persons living in the age-group have increased in number at the same rate as the total population.

In other words, the population at last census is to the present estimated population as the number living in the age-group at last census is to the number now living in the age-group. The method of estimating population was given at p. 421.

Then the $\frac{\text{Number of deaths in the age-group} \times 1000}{\text{Number living in the age-group}}$ gives the death-rate per 1000 living in the age-group.

The average death-rates observed in each of the age-groups during the years 1895 to 1899 in England and Wales are as follows:—

MEAN ANNUAL DEATH-RATES PER 1000 LIVING AT EACH GROUP OF AGES AND IN EACH SEX.

YEARS 1895 TO 1899 INCLUSIVE.

	Males.	Females.
Under 5	61·0	51·24
5–10	3·64	3·92
10–15	2·26	2·32
15–20	3·56	3·42
20–25	5·06	4·36
25–35	6·7	6·02
35–45	11·46	9·56
45–55	18·64	14·48
55–65	34·8	28·2
65–75	66·14	57·7
75–85	144·62	132·12
85 and upwards . .	281·7	258·16
All ages . . .	18·9	16·82

Sex.—In the years 1891–95 female mortality was lower than the male at all ages and at each individual group of ages, except between 5 and 20 years; it was equal at 5–10 and at 15–20, and was higher only at 10–15 years.

The higher mortality among adult males may be ascribed to occupational influences and greater intemperance.

In both sexes the death-rates at ages under 5 and over 55 are higher than their respective death-rates at all ages: in both sexes the rates at ages 5–45 are lower than those at all ages; but at ages 45–55 there is the following difference in the two sexes:—Males aged 45–55 have a death-rate equal to that of males at all ages; but females aged 45–55 still possess a death-rate lower than that of females at all ages.

In both sexes the death-rate is at its lowest point at ages 10–15, and is much lower between 5 and 35 than at earlier or later ages.

Of all the special death-rates at particular ages, none is of greater importance than the death-rate of children under 1 year of age or the infantile mortality.

Infantile mortality.—The ordinary method of calculation of death-rates is in this instance departed from, and for this reason, that whereas the population at other ages can be ascertained with fair accuracy by estimation from the results of the census, this cannot be said to be the case with regard to children under 1 year, since many in their first year are returned as "1 year old." It is therefore customary to state the infantile mortality as *so many deaths of children under* 1 *year of age per* 1000 *births in the same year.*

Infantile mortality is generally between 100 and 200 per 1000 births. During 1899 it was in England and Wales 163, in Lancashire 191, and in Westmorland only 109 per 1000.

Infantile mortality shows a very distinct age and sex incidence. It is distributed over the first year of life in unequal proportions, half of the mortality occurring in the first three months of life. It is greatest on the first day of life, and continues high throughout the first week, falling rapidly thereafter, and is lowest in the last three months of the first year of life. Infantile mortality is much higher among males than females, so much so as practically to neutralise the disproportion of the sexes at birth.

Environment has much to do with infantile mortality, which is higher in mining and industrial districts and in populous towns than in the rural and agricultural districts. The conditions of life in towns are less conducive to health than in more sparsely populated neighbourhoods, not only because the homes of the people are less sanitary, but also on account of concomitant influences, such as intemperance and the stress of the struggle for existence. Children of all ages suffer more than adults from the deprivation of air, sunlight, and good food, which is so common in towns, and infants especially succumb under these conditions. Marriage, occurring earlier in life in towns than in the country, results in the birth of infants by youthful mothers deficient in the knowledge of how to care for their firstborn; and it has been observed that infantile mortality is greater amongst the firstborn than the later-born members of families. The accidents of birth are prominently causative of infantile mortality. Premature birth may result from the unhealthy conditions to which pregnant women are exposed in towns, and these may also conduce to congenital debility in the full-term offspring. Industrial conditions contribute to swell the infantile death-rate; the mothers continue to labour in the factories throughout their pregnancy, and hasten back after parturition, to the detriment and neglect of their infants. Suckling is reduced to a week or two, or, perhaps more often, not begun, and improper feeding too often puts an end to the young life. Many lives may in future be saved, as mothers are now forbidden to return to factory life for one month after labour. If they were instructed as to the importance of proper nourishment in the rearing of infants, benefit would also result. Infantile mortality is lower among the better classes of the population than among the poor, since the former are fortunately placed under more hygienic conditions than the latter. Other influences which play a part in the production of infantile mortality are syphilis and alcoholism; and amongst the methods by which the latter increases its victims, there must not be forgotten the overlaying of an infant by a drunken parent, which is unfortunately too common an occurrence.

Causes of death in the first year of life.—From what has been said as to the factors of infantile mortality, the actual causes of death may be guessed. Thus, during the first month of life, the majority of deaths occur from premature birth, congenital defects and diseases, atelectasis, atrophy, and convulsions. Later, from the third to the sixth month, diarrhœa claims many victims, whether it be epidemic or casual. In the last three months of the first year of life the troubles associated with dentition contribute their share. Of the other zymotic diseases besides diarrhœa, whooping-cough is much the most fatal to infants, and its incidence occurs even in the early months of life. Measles also causes a good many deaths, but these occur mostly towards the end of the first year of life. Scarlet fever is not specially a disease of infantile life, and does not add largely to the infantile mortality.

Birth-rate and infantile mortality.—A high birth-rate may be associated with a high infantile mortality, since high birth-rates occur usually in towns and populous districts, where the prevailing conditions of life tend to cause mortality among infants. A high infantile mortality may occur independently of a high birth-rate, and may be concurrent with a low or moderate birth-rate.

Although there may be an increasing number of deaths of infants under 1 year associated with a high and increasing birth-rate, this does not necessarily mean an increase in the infantile mortality rate, for the ratio of deaths per 1000 births may remain the same.

Illegitimacy and infantile mortality.—Infantile mortality is higher among illegitimate than among legitimate children. This is ascertained by comparing the number of legitimate and illegitimate children who die in the first year of life per 1000 legitimate and illegitimate births respectively. Note this proper method of comparison; the illegitimate births or deaths must not be stated either as a percentage of the total births or deaths, or as a percentage of the legitimate births or deaths. Compare the infantile mortality in the two classes in this table—

	Legitimate.	Illegitimate.
Glasgow, 1894 . . .	138	267
Brighton, 1897 . . .	135	265

It is evident, therefore, that an illegitimate infant has much less chance of surviving its first year of life than its legitimate brother or sister.

Such influences as the hope of avoidance of shame, the absence of assistance at the labour, the poor food and deficient care subsequently accorded the unlawful arrival, all tend to lessen the prospects of survival of an illegitimate child.

Density of population and infantile mortality.—Overcrowding is one of the conditions which may be supposed to increase infantile mortality, especially in towns; but its influence is somewhat indirect. A high density of population per acre of ground, as shown by Dr. Newsholme, may exist without being associated with a high infantile mortality. The social conditions and unhealthy industries common in crowded communities probably contribute more than the number of inhabitants per acre to produce the high infantile mortality so frequent in such towns. The number of occupants per occupied room is a much better guide to the hygienic conditions of a neighbourhood than the number of persons to an acre. Overcrowding may be defined as existing when the number of occupants per room exceeds two.

A high infantile mortality may be expected to accompany mere density of population when such a condition of overcrowding exists.

Insurance of infants and infantile mortality.—Large numbers of children are insured by their parents, chiefly among the wage-earning classes, in order to provide for funeral expenses in case of their death at early years. The sum insured is legally restricted to £5 in the case of children under 5, and to £10 for children aged 5 to 10. From time to time instances occur of neglect and murder of children for the sake of the sum thus secured, but it does not appear that this is the case to such an extent as to increase the death-rate of insured as compared with uninsured infants.

Infant Life Protection Act.—The very high death-rate which exists among illegitimate children and the iniquitous practice known as baby-farming, with its associated cruelty and crime, instigated an attempt to diminish infantile mortality by legislation. The Infant Life Protection Act was passed in 1897, and its provisions for the supervision of those entrusted with the care of infants are given on p. 575.

(*c*) *Climate, Season, and Periodicity.*—*Climate.*—Climatic conditions have very definite illustration in the mortality statistics of different parts of the world, the geographical distribution of different diseases and their varying mortality in different climates being shown by the figures. In considering statistically the effects of climate, it is most important to make sure that the figures shall be cæteris paribus. It is useless, for instance, to compare the mortality from a disease in one climate with its mortality in another climate, unless the persons affected are alike in other respects, *e.g.* age, race, etc.

Season.—Death-rates vary very much with the season of the year. In this country most deaths occur in the first quarter of the year, and fewest in the third quarter; the rate is high in the winter months, and also in the heat of the summer, and is lowest in early summer and in the autumn. The curve of the general death-rate at all ages is a double one, high for the first three months of the year, falling rapidly from April to its lowest point in June, rising in July and the early half of August, and falling again until October, rising thereafter till in December it is the same height as in January. The summer rise is in the main due to deaths from epidemic diarrhœa, and the winter height to respiratory diseases. A mild winter lowers the mortality, especially of the old and feeble; while a cool, and especially a cool wet summer, lowers the mortality of infants by restricting the prevalence of diarrhœa. A very cold winter is extremely fatal to old people. Intestinal diseases are most prevalent in summer, and respiratory diseases in winter, and their curves of seasonal incidence are single waves with their crests in summer and winter respectively; combined, these curves mainly determine the double wave outline of the death-rate from all causes.

The curves for scarlet fever, diphtheria, and enteric fever are single wave curves; in each the crest occurs in the autumn (October and November), and the trough extends from February to August. The curves for smallpox and whooping-cough are double, having a trough from June to January, and a crest lasting on the whole from January to June, but interrupted by a distinct depression in February or March.

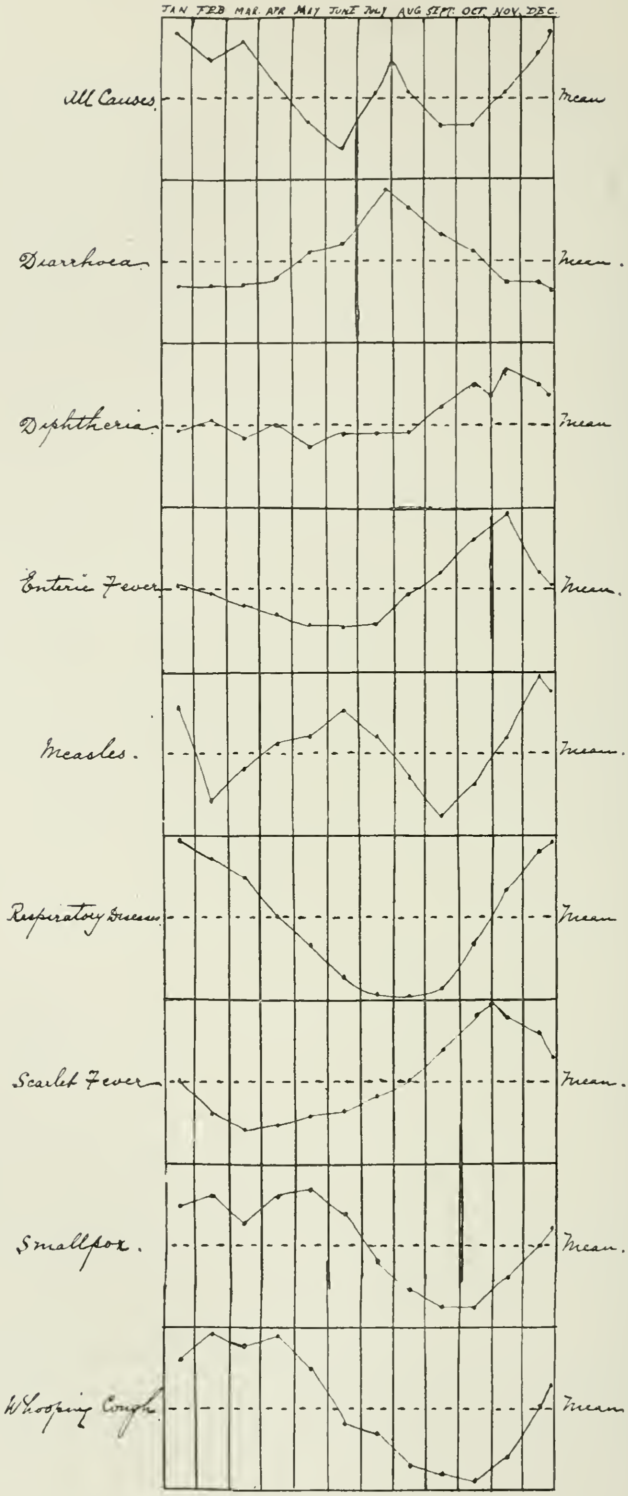


FIG. 187.—Diagram showing seasonal incidence of mortality from all causes and from certain diseases.

The curve of measles is definite and double; its crests occur in June and December, with intervening troughs lowest in February and September. Thus it happens that the effects of smallpox and whooping-cough on the general curve are counteracted by the effects of scarlet fever, diphtheria, and enteric fever, and that measles acts as a minor aid to diarrhœa and respiratory diseases in producing the curve of the general death-rate (Figs. 187, 188). Note in the latter figure the absence of any rise due to summer diarrhœa. In some diseases, moreover, season has an influence also on the ratio of deaths to attacks, the case mortality of some diseases being higher at certain seasons of the year than at others.

Periodicity.—Epidemic diseases recur at varying intervals, which may extend to a period of years, and we do not know the nature of the influences determining the transformation of an endemic disease into a spreading epidemic type which may end in pandemic prevalence. Further, we cannot tell the

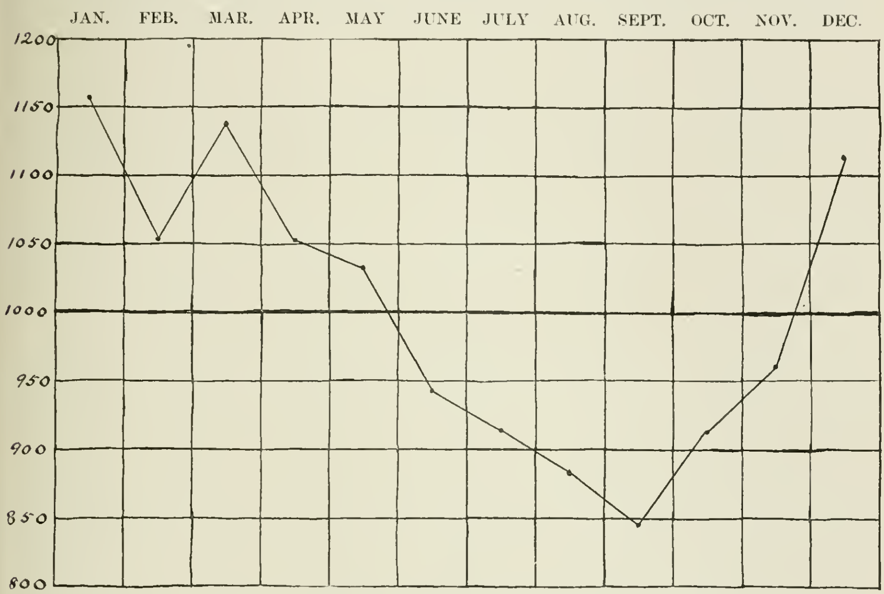


FIG. 188.—Seasonal incidence of deaths from all causes in Scotland, 1881–90, relative to a mean monthly mortality of 1000.

factors which determine its subsidence and its return to an endemic character. It has seemed that the accumulation of susceptible persons during the years of sparse prevalence may have something to do with the determination of a larger and more severe outbreak, but there must be other causes, probably connected with the life-history of the specific organisms, and with which we are at present unacquainted.

Cyclical waves of disease spread over communities, reducing largely the number of susceptible persons, and rendering the survivors immune. Then follow a series of years in which, though the disease is perhaps never absent and is occasionally epidemic, it is mild in type and selective in its incidence, after which the cycle is completed, and a form of the disease fatal in type and general in incidence recurs.

Thus the fundamental wave of scarlet fever has a cycle of from fifteen to twenty years, minor epidemics occurring every four to six years. Measles, too, shows a similar recurrence of phenomena, its mild epidemics occurring at intervals of one to two years. Charts showing these fundamental and accessory waves of disease have been prepared by Ransome, who aptly describes the former as "a vast wave of disease, upon which the lesser epidemics show like ripples upon the surface of an ocean swell."

(*d*) *Marital Condition.*—There is some indication that mortality is higher in unmarried adults than in married persons of similar ages, but definite statistics on the subject are not at present available. Certain it is that the proportion of unmarried persons per 1000 of the population in each sex above 15 years of age diminishes at each successive age period thereafter. If the mortality were no greater in the unmarried than the married, this proportional diminution should cease at about 55 years of age, when the influence of marriage in the diminution of the unmarried section of the population might be expected to have terminated.

This is all that can be said in the absence of special death-rates calculated from the respective deaths and population in each age- and sex-group of the married and of the unmarried.

(*e*) *Density of Population.*—The density or aggregation of the population may be calculated in relation to area in two ways—(*a*) The number of persons living to one square mile of area, *i.e.*—

$$\frac{\text{Population}}{\text{Area in square miles}} = \text{Density.}$$

This is the average population of each unit of area, *i.e.* 1 square mile.

(*b*) The average number of acres to one person (areality of Farr)—

$$\frac{\text{Area in acres}}{\text{Population.}} = \text{Density.}$$

This is the average area to each person, the unit of area in this case being the acre.

In England and Wales in 1901 the density of the population according to these two methods was—(*a*) 557 persons to 1 square mile; (*b*) 1·15 acres to 1 person.

The apparent density, as thus stated, is always less than the actual density, owing to the inclusion in the area of all uninhabited portions of the country, such as parks, lakes, and moors.

A better test of the density of the population would be to state it in addition in terms of the number of occupants per occupied room, or persons living in each occupied room.

TENEMENTS WITH LESS THAN FIVE ROOMS (E. & W. 1891).

	Number.	Number having more than two Occupants per Room.	Percentage showing Over-crowding.
One room . .	286,946	92,259	32·15
Two rooms . .	697,322	184,231	26·42
Three rooms .	756,756	120,031	15·86
Four rooms . .	1,464,681	85,132	5·8

The standard of overcrowding is two persons to one occupied room, yet, judged by this standard, 11·23 per cent. of the English population lived in overcrowded tenements at the 1891 census.

The preceding table shows the percentage of overcrowded tenements in England and Wales based on a standard of two occupants per room.

The death-rate among persons living in one- and two-roomed houses is found to be higher than among persons living in three- and four-roomed houses, and is more than twice as high as among persons living in houses having five or more rooms.

The mortality increases with the density of population, and is therefore higher in urban than in rural districts. The relation between the mortality and the density is not one of direct proportion. At first it was thought that the mortality increased as the sixth root of the density of the population, *i.e.*, if m and m' be the mortality in two populations, and d and d' be the densities in the same populations—

$$m' : m :: \sqrt[6]{d'} : \sqrt[6]{d}, \text{ or } \frac{m}{m'} = \sqrt{\frac{d'}{d}}.$$

This proportion, however, was subsequently modified, as a figure nearer the eighth root of the densities was found to be more accurate, and the relation was then stated thus—

$$m' : m :: d'^{0{\cdot}1198} : d^{0{\cdot}1198}, \text{ or } m' : m :: d'^{0{\cdot}12} : d^{0{\cdot}12}.$$

Now, however, although density and mortality generally increase or decrease together, the relation is recognised as being too complex to be expressed by any such formula.

The causes of the high death-rate associated with the aggregation of the populace on a limited area are—(1) Contamination of air, water, and soil, more particularly of the air, for many towns with dense populations now possess pure and wholesome water supplies from distant sources, and are efficiently drained. (2) Overcrowding marks its influence on the death-rate, for those towns which have the greatest proportion of their population living in one-roomed houses have death-rates higher than towns whose inhabitants are more fortunately situated. (3) Facilities afforded for the spread of infectious diseases, both by direct contact and aerial transmission. (4) The excessive prevalence of phthisis on account of the absence of fresh air and sunlight in the crowded houses. Zymotic diseases, phthisis, and respiratory diseases exist in excess in houses of only one or two rooms and in back-to-back houses. (5) Deficiency of food and clothing and uncomfortable homes, which are the concomitants of poverty and prevail in the lowest stratum of urban populations, all tend to increase mortality. Alcoholism in itself, and as a cause of these conditions, is a potent factor in increasing disease. (6) Industrial conditions, unhealthy occupations, vile emanations from factories of various kinds, and accidents, add to the mortality of towns.

Among occupied males aged 35 to 65 years, the mortality in industrial districts exceeds by 30 per cent. that of all occupied males at these ages.

In agricultural districts, on the other hand, the mortality among occupied males at these ages is 30 per cent. less than that of all occupied males at these ages.

(*f*) *Occupational Mortality.*—The death-rates prevalent in different occupations vary very much, and comparisons as to the healthiness or unhealthiness of different trades form an important section of vital statistics.

At the outset a difficulty arises in the estimation of occupational mortality, owing to the vague descriptions of their occupation furnished by many individuals in their census returns; *e.g.* engineer, if not further defined, might mean either a civil engineer, a driver of locomotives or other engines, or an electrical engineer. Another element of uncertainty consists in change of occupation; thus, a worker at a laborious trade, and injured in health by it, may undertake a lighter occupation or cease to work at all, and his death, instead of being credited to the unhealthy trade, swells the mortality of the easier work or of the "unoccupied" class. Moreover, there is a certain selection of lives constantly taking place in the choice of a trade; a weakly man is not likely to select a very arduous occupation, and consequently the very laborious trades are recruited in the main from the stronger members of a family.

Notwithstanding such sources of error, occupational statistics are of great value, but must be regarded as modified to some extent by these considerations. Estimates of occupational mortality are restricted to males between the ages of 25 and 65, since it is believed that between these ages the effect of occupations on mortality will be most in evidence. This is certainly true of the labours of the industrial classes, though perhaps less true of the professional classes, in whom the effects of their occupation may cause mortality at later ages than 65.

Methods of Calculation of Occupational Mortality for purposes of Comparison.—These may be divided into erroneous and correct.

1. *Erroneous.*—(*a*) The mean age at death of the employees is sometimes taken as a test. This is the sum of the ages at death divided by the number of deaths. It is not a good comparative estimate of the mortality of an occupation, since it depends on the ages of those engaged in the occupation, and some occupations may employ old men, and others young men, exclusively.

(*b*) The number of deaths per 1000 of the employees may be cited, but this is not a fair method of comparison, since the age distribution of the workers in different occupations is seldom alike, and the age constitution of the workers will notably affect the deaths per 1000.

2. *Correct.*—The death-rates in any occupation are ascertained from—(1) The average number of deaths in each age-group, 25–35, 35–45, 45–55, 55–65, which occurred during three years among males engaged in that occupation. The census year and adjacent years are usually taken, *e.g.* 1890, 1891, and 1892. (2) The population of males of each age-group disclosed by the census (1891) as engaged in that occupation.

$$\text{Then}\quad \frac{\text{Deaths in one age-group} \times 1000}{\text{Working population in that age-group}} = \begin{array}{c}\text{Death-rate of that age-group}\\ \text{in that occupation.}\end{array}$$

This is done for each age-group and each occupation, and the results noted.

The Method of Comparing Different Occupations will be considered next. This is done by means of a Comparative Mortality Figure, calculated for each occupation—the Occupational Comparative Mortality Figure. From the deaths of the same three years, *e.g.* 1890–92, and the census of 1891, there is ascertained the number of men aged 25–65 in the whole population, out of whom 1000 deaths would occur in a year.

This number was found for the 1891 census to be **61,215**, divided as follows:—

22,586 in the age-group 25–35.
17,418 ,, ,, 35–45.

12,885 in the age-group 45–55.
8,326 „ „ 55–65.

This number, thus divided, is taken as a *standard population*, and the number of deaths in it, namely, 1000, is taken as the Comparative Mortality Figure of "all males" aged 25–65.

The 1000 is the sum of the deaths in each age-group, *e.g.* the death-rate of all males aged 25–35 was for 1890–92 = 7·67. This rate gives 173 deaths in a population of 22,586.

$$\frac{22,586}{1000} \times 7 \cdot 67 = 173.$$

In the age-group 35–45 the death-rate was 13·01, and this rate gives 227 deaths in a population of 17,418.

In the age-group 45–55, with a rate of 21·37, and a population of 12,885, 275 deaths would occur.

In the age-group 55–65, a population of 8326, subjected to a death-rate of 39·01, would yield 325 deaths.

And 173 + 227 + 275 + 325 = 1000.

In order to compare with this figure 1000, the mortality of each separate occupation, take the death-rates found to exist in each group of ages in an occupation, and calculate the number of deaths that would occur in each age-group of the standard population. Add together the deaths thus calculated, and so obtain a figure which is the Comparative Mortality Figure for that occupation.

An example will show this method clearly—

Age-Group.	Standard Population, Census 1891.	1890–92. Death-rate per 1000 in each Age-Group.		Calculated Number of Deaths in each Age-Group.	
		All Males.	Doctors.	All Males.	Doctors.
25–35 . . .	22,586	7·67	6·69	173	151
35–45 . . .	17,418	13·01	14·92	227	260
45–55 . . .	12,885	21·37	21·04	275	271
55–65 . . .	8,326	39·01	34·16	325	284
Comparative Mortality Figures				1000	966

The Comparative Mortality Figures of various occupations, as ascertained from the figures of 1890–92, are as follows:—

All males, 1000.
Occupied males, 953.
Unoccupied males, 2215.

Clergy	533	Artists	778
Gardeners	553	Lawyers	821
Farmers	563	Fishermen	845
Teachers	604	Shopkeepers	859
Agricultural labourers	666	Commercial clerks	915
Domestic servants	757	Shoemakers	920
Ironstone miners	774	Coal miners	925

All miners	935	Lead miners	1310
Doctors	966	Tin miners	1409
Tailors	989	Brewers	1427
Law clerks	1070	Glass manufacturers	1487
Printers	1096	Cutlers	1516
Plumbers	1120	Innkeepers	1659
Stone quarriers	1176	Potters	1706
Musicians	1214	Lead-workers	1783
Transport service	1216	Filemakers	1810
General labourers	1221		

The very high figure, representative of the mortality amongst unoccupied males, is due to the inclusion in this class of large bodies of persons, such as—(*a*) *The insane*, who are very liable to phthisis and nervous diseases, and are incapacitated for any occupation; (*b*) many persons formerly employed, but through ill health having no occupation prior to death; (*c*) persons retired from business owing to old age or disease; (*d*) persons physically unfit for work all their lives.

The Comparative Mortality Figures given above represent deaths from all causes, so that in order to ascertain the prevalence of special diseases in particular occupations and to compare these, it is necessary to divide the Comparative Mortality Figures into components representative of particular diseases.

DISEASE COMPARATIVE MORTALITY FIGURES.

(From Part II. of Supplement to 55th Report of the Registrar-General.)

D.C.M.F.	Innkeepers and Inn Servants.	Doctors.	All Males.	Diseases.
D.C.M.F.	46	51	34	Influenza.
,,	94	14	13	Alcoholism.
,,	16	3	7	Rheumatic fever.
,,	12	8	2	Gout.
,,	53	43	47	Cancer.
,,	311	105	192	Phthisis.
,,	19	22	7	Diabetes.
,,	148	122	102	Diseases of nervous system.
,,	30	28	24	Valvular heart disease.
,,	7	6	6	Aneurism.
,,	153	96	102	Other circulatory diseases.
,,	89	12	88	Bronchitis.
,,	165	93	107	Pneumonia.
,,	10	7	7	Pleurisy.
,,	34	13	22	Other respiratory diseases.
,,	5	0	3	Hernia.
,,	174	60	29	Liver diseases.
,,	42	49	26	Other digestive diseases.
,,	59	56	28	Bright's disease.
,,	27	23	16	Other urinary diseases.
,,	0	0	1	Plumbism.
,,	47	37	56	Accident.
,,	29	41	15	Suicide.
,,	89	77	66	All other causes.
Comparative Mortality Figure	1659	966	1000	All Causes.

These components are Disease Comparative Mortality Figures (D.C.M.F.), and are ascertained for twenty-four classes of disease, namely—(1) Influenza; (2) alcoholism; (3) rheumatic fever; (4) gout; (5) cancer; (6) phthisis;

(7) diabetes; (8) nervous diseases; (9) valvular heart disease; (10) aneurism; (11) other diseases of circulatory system; (12) bronchitis; (13) pneumonia; (14) pleurisy; (15) other diseases of respiratory system; (16) hernia; (17) liver diseases; (18) other diseases of digestive system; (19) Bright's disease; (20) other diseases of urinary system; (21) plumbism; (22) accident; (23) suicide; (24) all other causes.

The sum of the twenty-four Disease Comparative Mortality Figures of any occupation thus equals the Comparative Mortality Figure of that occupation. The proportions in which it is allocated over the various diseases are decided in any occupation by the mortality returns in the three years, *e.g.* 1890–92, showing the diseases which contributed to the deaths in that occupation.

A specimen table is given (p. 444), showing the Disease Comparative Mortality Figures for all males, for doctors, and for innkeepers. The Disease Comparative Mortality Figures show that the incidence of these diseases is great in the following occupations:—

INFLUENZA.—Medical practitioners.

ALCOHOLISM.—Innkeepers and inn servants. The full effect of this disease is not shown in its own column; it increases deaths under other headings, *e.g.* liver diseases (of which cirrhosis is largely alcoholic), phthisis, nervous disease, urinary disease, and gout.

RHEUMATIC FEVER.—Copper miners, hotel servants, miners.

GOUT.—Innkeepers, plumbers.

CANCER.—Chimney-sweeps.

PHTHISIS.—Inn and hotel servants, hawkers, lead miners, filemakers, cutlers, potters, unoccupied males. It is notable that phthisis mortality is low in coal miners.

DIABETES.—Lawyers, doctors, innkeepers.

NERVOUS DISEASES.—Lead-workers, filemakers, innkeepers, unoccupied males.

VALVULAR HEART DISEASE.—Chemical manufacturers, fishermen, potters, and hairdressers.

ANEURISM.—Copper miners, seamen, bargemen, dock labourers.

BRONCHITIS.—Potters, chemical manufacturers, tool and glass makers.

PNEUMONIA.—Coalheavers, iron and steel manufacturers, dock labourers.

PLEURISY.—Chemical manufacturers, tin miners, unoccupied males.

LIVER DISEASES.—Publicans, doctors.

BRIGHT'S DISEASE.—Filemakers, innkeepers, doctors, brewers.

PLUMBISM.—Lead-workers and filemakers.

ACCIDENT.—Bargemen, seamen, coal workers, railway employees.

SUICIDE.—Doctors, innkeepers, unoccupied males.

The Disease Comparative Mortality Figures show much interesting information, of which the following items may be emphasised:—

(A) *Occupied and Unoccupied Males.*—The Disease Comparative Mortality Figure is higher in unoccupied than in occupied males in all the twenty-four classes of disease, except bronchitis, rheumatic fever, and plumbism. In the occupied males the chief fatal groups are respiratory diseases, phthisis, and circulatory and nervous disease. In the unoccupied males, nervous diseases, phthisis, respiratory and circulatory diseases, and cancer cause most of the deaths.

Among occupied males the D.C.M.F. for respiratory diseases exceeds that of phthisis, but among unoccupied males the phthisis figure is larger than that of respiratory disease. This is explained by the fact that occupied males with phthisis drift into the unoccupied class, and also because insane persons, who form a large portion of the unoccupied class, are prone to phthisis.

Although in all occupied males the respiratory D.C.M.F. exceeds that of phthisis, it is not so in about one-third of the occupations, namely—

Occupations carried on in close and confined air.	}	Phthisis dominant and increased.
,, associated with alcoholic intemperance.		
,, protected from weather inclemency.	}	Respiratory disease diminished.
,, healthy outdoor.		

In these occupations the phthisis D.C.M.F. exceeds the respiratory.

(B) *Effects of Breathing Impure Air.*—Impure air producing increased fatality amongst classes of workers may be divided into two kinds, according as the air is merely vitiated or is dust-laden.

1. *Foul air.*—The increased mortality from this cause is shown in the greater prevalence of phthisis and respiratory diseases amongst bookbinders, printers, musicians, tailors, and drapers, in all of whom the mortality is from two to two and a half times that from the same diseases in the agricultural population.

2. *Dust-laden air.*—The kind of dust has much to do with the production or otherwise of lung diseases. The dust of coal and wood is least injurious, that of metals and stones most injurious, while flour and the dust of textile factories are intermediate. Phthisis and respiratory diseases are most fatal amongst potters, cutlers, tin miners, filemakers, and stoneworkers, who show a mortality from these diseases four and a half to two and a half times as great as the corresponding mortality amongst agriculturists.

The exemption of coal miners from a heavy phthisis mortality is specially noteworthy, and is believed to be due to the stringent regulations which have resulted in good ventilation in mines, to the slightly irritant nature of carbon particles, and possibly also to an actual deterrent effect of the carbon on the life and activity of the tubercle bacillus.

(C) *Mortality from Phthisis and Respiratory Diseases*—

1. Phthisis.—The mortality from this disease has been reduced in most occupations during the decade 1881–90, but has increased 2 per cent. in filemakers, and 9 per cent. in cutlers. Reductions of 12 to 29 per cent. have taken place amongst colliers, blacksmiths, woolworkers, cotton spinners, tin miners, potters, and ironstone miners; and 2 to 10 per cent. in bakers, carpenters, stone quarriers, and bricklayers.

2. Respiratory Diseases.—There has been a general increase of 15 to 28 per cent. in the mortality from this group in all trades, except tin miners and ironstone workers, in whom it has respectively decreased 13 per cent. and 3 per cent. Note, then, that during the decade 1881–90, phthisis decreased in all trades except two, and respiratory diseases increased in all trades except two.

(D) *Lead-Poisoning.*—In addition to deaths returned definitely under the heading plumbism, the effects of lead-poisoning are seen in the excessive prevalence of urinary diseases, gout, and nervous and circulatory diseases amongst the occupations exposed to lead-poisoning. It is most fatal to lead-workers and filemakers, potters, plumbers, glaziers, and painters, and less so to lead miners and printers.

(E) *Alcoholism.*—Alcoholic poisoning adds to the D.C.M.F., not only in its own column, but also by inducing cirrhosis of the liver, nervous diseases, phthisis, Bright's disease, gout, and suicide. All these are greater than normal in trades specially liable to alcoholic excess.

Innkeepers and inn servants, brewers, butchers, chimney-sweeps, dock-labourers, and cabmen have high mortality figures from these diseases.

II. SPECIAL DEATH-RATES FROM INDIVIDUAL DISEASES.

Death-rates are ascertained for each individual disease, or for groups of diseases. The usual method of stating such death-rates is as the number of deaths caused annually by the particular disease per thousand or per million of the entire population, *e.g.* the death-rate from phthisis in the year 1881–90 averaged 1·724 per 1000, or 1724 per million of the population. This method could be improved by stating the deaths from each individual disease at a given age-group as so many per thousand of the population living at the same age-group. Such a plan, however, would involve so many different death-rates for each disease, that it is only required in comparative statistical work, and for ordinary purposes a general death-rate for each disease suffices. Another useful method of stating mortality from particular diseases is case mortality or *fatality*, *i.e.* the proportion of deaths to persons attacked by the disease. It is usually stated as a percentage.

By this means the differences existing between the virulence of separate epidemics of the same disease, or of the beginning and end of the same epidemic, are brought out in figures. Case mortality should be considered, not only with regard to the general fatality at all ages, but also primarily, according to the age and sex of those attacked. The deaths at one age and in one sex should be stated as a percentage of those of that sex and age attacked. Some diseases are much more fatal at certain ages than at others, and some are more fatal to one sex than to the other. Inferences should not be drawn too absolutely from the fatality met with in small epidemics, owing to the paucity of data furnished by such outbreaks. This error is specially liable to occur if the cases are divided out into numerous age- and sex-groups, thus reducing the number of cases in a group so that even one or two deaths may appear as a large percentage. A third method is to state the mortality from a particular disease as a proportion of the deaths from all causes. This is of value as showing the proportions in which given diseases have contributed to the mortality of any one year, but should not be used for comparative purposes, since it is not statistically correct to compare ratios of two variable factors.

COMMUNICABLE DISEASES.

Diarrhœa.—This is a somewhat generic term, but represents in the main the mortality from epidemic diarrhœa, or, as it is now often termed, zymotic enteritis. Deaths from simple diarrhœa, as distinct from the epidemic form, are frequently returned now as enteritis or gastro-enteritis, though some are also registered under this heading. Further, the mortality from dysentery is assigned to this section; but as that disease is not now common in this country, it does not add much to the figures.

1. *Case Mortality.*—This is not known, as the cases are not notifiable, but it must be very high in infants.

2. *Death-rate.*—Epidemic diarrhœa causes excessive mortality among

young infants, and this would be better disclosed by the figures if its death-rate were stated in the same way as infantile mortality, namely, as the number of deaths from diarrhœa per 1000 births occurring in the same year. Its death-rate, calculated in proportion to population at all ages, does not sufficiently reveal its lethality, though it has amounted to ·97 per 1000.

Annual deaths from diarrhœa per million of the population have fallen from 935 in 1871–80 to 674 in 1881–90, and to 652 in 1891–95, but there has been latterly a great rise. If the figures relating only to the first year of life be similarly stated, there are about 16,000 deaths per million.

The lessening of the diarrhœal death-rate is probably due to better sanitation, but there is still room for very great improvement. Indeed, the average for the three years 1895–97 was as much as 753 per million.

3. *Age.*—Diarrhœa causes an enormous mortality in the first year of life, but it is also a fatal disease in old age, the death-rate above seventy-five years of age being very high. It is therefore a serious disease of the extremes of life.

4. *Sex.*—Diarrhœa affects both sexes, but has a preference for males.

5. *Season.*—Epidemic diarrhœa prevails most in July and August, coincidently with certain temperature conditions of the air and soil. It does not occur in the cold season to any large extent.

Diphtheria.—1. *Case Mortality.*—This varies in different places and in different epidemics. The general fatality at all ages is 16 to 25 per cent. of the cases.

2. *Death-rate.*—The death-rate from diphtheria has risen in recent years, but in part this is probably due to more correct certification and diagnosis. There were annually 121 deaths in 1871–80, 163 in 1881–90, and 253 in 1891–95 per million of the population, or a death-rate per 1000 in later years of ·25. It may be expected that this will be reduced in later statistics owing to the more extensive use of antitoxin. For 1899, however, the figure was 293 per million, and along with croup 325 per million.

3. *Age.*—Diphtheria is less fatal in infants under 1 than in children from that age up to 5. The case mortality at ages under 5 often approaches 40 per cent., and at ages from 5 to 10 may be 20 per cent.

Its fatality has not varied so much as that of scarlet fever. Its attack-rate and death-rate follow one another closely, though some epidemics have a higher attack rate, and others a higher death-rate. In recent years the incidence of diphtheria has mainly fallen on children at ages when school attendance is compulsory.

4. *Sex.*—Diphtheria is slightly more fatal to females than to males at each group of ages.

5. *Locality.*—Diphtheria, which was formerly a disease of rural districts, has now very markedly become a disease of towns.

6. *Season.*—Diphtheria produces its greatest mortality in the autumn and early winter.

7. *Climate.*—Like scarlet fever and some other diseases, diphtheria is more prevalent in years of deficient rainfall.

Enteric or Typhoid Fever.—1. *Case Mortality.*—The case mortality at all ages varies in different places; in London it is between 15 and 20 per cent., but in Edinburgh 10 to 15 per cent. represents its usual severity. In the South African Field-Force the case mortality has probably been much the same as in London, though in some places and at certain times a higher figure has been reached. The case mortality varies in the two sexes, and at different ages. It is higher above 15 years of age, and increases with advancing life thereafter; under 15 it does not exceed 10 per cent., but in middle-aged persons may be 30 or 40 per cent. The case mortality in males at all ages is 3 to 4 per cent. higher than in females.

2. *Death-rate.*—The death-rate of typhoid has declined in recent years, chiefly owing to its lessened prevalence, the result of hygienic reform, and not to any marked reduction in its case mortality. The annual deaths, which numbered 322 per million in 1871–80, fell to 196 in 1881–90, and to 173 in 1890–96. There has, however, been a more recent rise, the 1899 figure being 199 per million. The death-rate per 1000 varies from ·15 to ·2. The decline in the death-rate has been mostly at ages under 10 and over 55 years. The following table shows some interesting comparisons:—

Enteric Fever.	Per 1000.
England and Wales, 7 years, 1890–96	0·17
,, ,, 10 ,, 1881–90 {Males, aged 20–25}	0·34
Troops, United Kingdom, 1887–96	0·26
,, India, 1886–95	5·16
,, South Africa, 1885–89	1·37
,, ,, ,, 1892–96	1·76
,, ,, ,, Field Force, 1900 . . . . probably	10·00

3. *Age.*—Enteric fever chiefly attacks young people, those between 10 and 25 years of age bearing its main incidence.

4. *Sex.*—Males are more liable to attack than females at all ages and at each group of ages, and, moreover, suffer a higher death-rate from the disease at all ages and at most of the age-groups.

5. *Season.*—In this country there is most enteric in the autumn, and most of the deaths occur in October and November. Its seasonal relation is constant, and the decrease of typhoid has most affected the autumnal and winter prevalence, the difference during the minimum period being less marked. In New York, enteric both begins and reaches its maximum two months earlier than in London, and this period coincides with the time when the mean monthly temperature attains its maximum. In Glasgow, the seasonal curve of enteric is a double one, the main rise being in autumn, with a small accessory rise in spring, and the latter has been noticed to be absent after a severe frosty winter. In Natal, the maximum is in December and January, the minimum in June to August. There is thus a single curve, but this may be disturbed by a subsidiary rise in May.

Erysipelas.—1. *Case Mortality.*—The case mortality is from 4 to 7 per cent.

2. *Death-rate.*—The death-rate from erysipelas in England and Wales has declined within the last twenty years from an average of 80 per million to 50 per million.

3. *Age.*—Its incidence is chiefly on persons in the prime of life, between the ages of 20 and 45 years; but children are very liable to contract erysipelas.

4. *Sex.*—There is no preference for either sex, but puerperal women are specially susceptible.

5. *Season.*—Erysipelas is common in the spring and in dry years.

Febricula.—The death-rate from this cause has declined, and is now only

8 per million. No doubt the cases which in former times were returned under this head are now more often returned as enteric fever. The disease most frequently affects adolescents and young adults. In this country children are commonly attacked. The sexes seem to be equally liable.

Influenza.—1. *Case Mortality.*—This is low, being from ·1 to ·16 per cent.

2. *Death-rate.*—The death-rate amounts to 390 per million.

3. *Age.*—The disease is very lethal to old people.

4. *Sex.*—The death-rate is slightly higher amongst males than amongst females.

5. *Season.*—Influenza is most fatal in winter and spring.

Measles.—1. *Case Mortality.*—Measles has a low case mortality, but the disease is so prevalent that it contributes largely to the general zymotic death-rate. In Edinburgh, in 1881–90, the case mortality varied between 6 per cent. and 1·5 per cent., and was on the average 3 per cent.

2. *Death-rate.*—The average annual mortality from measles in the whole country has not varied much of late years. The rate per million was in 1871–80, 378; in 1881–90, 440; in 1891–95, 408; or stated per 1000 of the population, ·37, ·44, and ·4 respectively. In 1899 it was only ·3 per 1000.

3. *Age.*—Measles prevails most in the third, fourth, and fifth years of life, but is most fatal in the second year of life, and to a smaller extent in the first and third years. The death-rate falls very rapidly at ages above 5, and few children die of measles above that age. The advantage of preventing or deferring attacks of measles during early life is thus twofold; the child is not only less likely to take the disease after 5 years of age, but much less likely to die of it if it occur.

4. *Sex.*—The sexes are equally liable to measles, but the death-rate is higher among males under 5 years of age as compared with females of the same age. At higher ages measles is slightly more fatal to females than to males.

5. *Locality.*—There are more cases of measles in urban than in rural districts, owing in part to the facilities the former afford for its spread from child to child. It is certainly more fatal in towns than in the country.

6. *Season.*—The seasonal incidence of measles, as shown by its mortality, points to its greatest virulence in June and December. The curve of its death-rate is therefore a double one, having its crests in May and June, and in November to January, with troughs in the intervals. In London the winter crest is the higher; but in Paris, Berlin, and New York the chief rise is in the summer. Possibly a considerable part of the summer rise is due to the concurrent prevalence of rubeola, which is included under the term "measles."

Phthisis.—1. *Death-rate.*—The death-rate from phthisis is 1·5 per 1000 of the population, and from other tubercular diseases ·7 per 1000.

Age.—2. The greater part of the phthisis mortality now occurs at ages 35–45, whereas formerly it occurred at 25–35, or even at younger ages.

3. *Sex.*—The decline in the phthisis death-rate has been most marked in females, though very considerable even in males. The comparative decrease is chiefly seen at the higher ages in females. Phthisis is more fatal to males than to females. The mortality caused by phthisis is still enormous; thus, in 1896, 11·6 per cent. of the total English mortality was due to tubercle, and of this 7·6 was the result of phthisis.

The decline in phthisis mortality is both real and apparent: real, owing to improved hygiene and better methods of treatment; and apparent, owing to conditions formerly returned as phthisis now being more accurately defined and entered under such headings as tuberculosis or respiratory diseases. The latter is not a very important factor, since there has been no increase of deaths from respiratory diseases at those ages at which phthisis causes its highest mortality.

Puerperal Fever.—This term covers many different pathological and clinical conditions. Its death-rate, stated in proportion to population, amounts to 1·8 per 1000; but since the disease is confined to parturient women, its death-rate should be stated rather in terms of the number of births than the number of the whole population.

From 1894–99 puerperal fever and accidents of child-birth caused 4·76 maternal deaths to every 1000 live births. From puerperal fever alone about 2·5 deaths of mothers occur for every 1000 children born alive.

Puerperal mortality is high at the first confinement, much less at subsequent confinements up to the fourth, and then increases with each later confinement, possibly owing to the increasing age of the mother. The ninth and subsequent confinements have a higher puerperal mortality than even the first.

The age of the mother influences the risk, for first confinements are more dangerous at ages above 28 to 30 years. The risk is greater among the unmarried than the married, and this is more evident at the lower ages. Meteorological conditions may influence the prevalence of puerperal fever; at any rate it is more frequent in years of deficient rainfall, in this particular resembling scarlet fever, diphtheria, erysipelas, and rheumatic fever.

Scarlet Fever.—1. *Case Mortality.*—The case mortality of scarlet fever is about 12 per cent. at ages under 5, but much smaller at higher ages.

2. *Death-rate.*—The average death-rate per million of the population in recent years has been 1871–80, 716; 1881–90, 334; 1891–95, 182, showing a fall from ·7 to about ·2 per 1000 of the population. In 1899 it further fell to ·1 per 1000. This fall in the death-rate might be due either to diminished prevalence of the disease, its fatality remaining the same, or to diminished fatality with or without diminished prevalence. There is some evidence to show that the disease has been less virulent in recent years.

3. *Age.*—Scarlet fever is largely a disease of childhood, but is less fatal to infants under 1 year than to children of 2, 3, 4, and 5 years.

4. *Sex.*—The case mortality is higher among males at all ages, and also at ages under 10; but at adult ages females suffer a higher mortality than males.

5. *Season.*—In most places the greatest mortality from scarlet fever occurs in autumn and at the end of the year, but in London it is often highest in the early months of the year. In London, children under 5 are most often attacked at the end and beginning of the year.

6. *Climate.*—Scarlet fever is most prevalent in years of deficient rainfall.

Smallpox.—Smallpox in this country, as in others, has very greatly decreased during the nineteenth century. From being one of the largest contributors to the general death-rate, and one of the most lethal diseases to which the population was exposed, it has declined in deadliness, and now produces only a small number of deaths. It is appalling to think that of every 100 deaths in the English population in 1796, 18·5 were due to smallpox. Smallpox then caused many more deaths than measles or whooping-cough, whereas nowadays these diseases cause more deaths than smallpox. In fact, so often did smallpox cause more than 10 per cent. of the total deaths from all causes, that twenty-nine epidemics during the eighteenth century reached this proportion. No epidemic of the nineteenth century has done so. During the latter half of the eighteenth century and the early years of the nineteenth century, inoculation of smallpox was practised, but this was finally rendered illegal in 1840. Inoculation did not increase the prevalence of smallpox, since in those days nearly every one had smallpox at some time or other in their lives, but the inoculated form was of a milder type. The disadvantages of inoculated smallpox were that it was a general illness, and not a merely local disease at the point of inoculation, and that it was communicable from person to person. Its advantage was that it substituted a possibly mild type of smallpox for a possibly severe and even fatal attack, and that it usually conferred immunity from future attack.

Attack Rate.—The attack rate of a disease is the number of persons attacked out of every 100 known to have been exposed to infection. In the case of smallpox the vaccinated have a much smaller rate of attack than the unvaccinated.

The following table shows the percentage of persons attacked out of those living in certain infected houses during recent epidemics :—

SMALLPOX ATTACK RATE.

Place.	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
	Under 10 Years.		Over 10 Years.	
Leicester . . .	2·5	35·3	22·2	47·6
Warrington . .	4·4	54·5	29·9	57·6
Sheffield . . .	7·9	67·6	28·3	53·6
Gloucester . . .	8·8	46·3	32·2	50·0
Dewsbury . . .	10·2	50·8	27·7	53·4

Some of these towns are well vaccinated, others are badly vaccinated communities, but in every instance the unvaccinated suffered more than the vaccinated.

The figures further show the diminution in the protection afforded by vaccination. The vaccinated over 10 years suffered more heavily than the vaccinated under 10 years. One of the best evidences of the protective value of vaccination is the very small attack rate among nurses and others in smallpox hospitals, who are constantly exposed to infection, and are all vaccinated and re-vaccinated. Their attack rate is never high, and is very frequently nil.

The statistics of Flinzer with regard to the Chemnitz outbreak, 1870–71, are here tabulated :—

	Population.	Percentage Population.	Number of Cases.	Persons Attacked per cent.	Fatality per 100 Cases.
Vaccinated	53,891	83·87	953	1·76	·73
Unvaccinated . . .	5,712	8·89	2643	46·27	9·16
Persons survived previous attack of smallpox	4,653	7·24	...	...	...
Total	64,255	100·00	...	...	..

In this country the respective numbers of the vaccinated and of the unvaccinated in a given community are not accurately known. There is thus a hiatus, which a knowledge of these numbers would supply, in the statistics regarding smallpox. Approximately, however, the numbers can be estimated from the vaccination returns, which show annually the numbers of births, of successful vaccinations, of those insusceptible to vaccination, of deaths prior to vaccination, of postponed vaccinations, of deaths from smallpox, and of those unaccounted for and not vaccinated. The proportion of these latter in Scotland is from 2 to 3 per cent., but in England the proportion is very much higher, and in certain places the majority of the births are unaccounted for as regards vaccination.

Case Mortality.—The fatality of smallpox varies in different epidemics, just as the fatality of other infectious diseases, but it is always heavier in the unvaccinated than in the vaccinated. The case mortality at all ages in six recent epidemics was among the vaccinated 5·2 per cent., and among the unvaccinated 35·4 per cent. Differentiation, according to age, shows that the fatality among the unvaccinated was greater than among the vaccinated, both under and above 10 years of age.

	Under 10.	Over 10.
Vaccinated	·2·7	5·4
Unvaccinated . . .	36·0	34·3

The advantage of the vaccinated over the unvaccinated, as regards escape from death when attacked by smallpox, may be calculated from the case mortality in the respective groups. Thus, if the fatality amongst the vaccinated adults in a certain district be 5 per cent., and amongst the unvaccinated adults 35 per cent., the former are found to possess an advantage of 85·7—

$$35 : 5 :: 100 : 14{\cdot}3. \quad \text{Then } 100 - 14{\cdot}3 = 85{\cdot}7.$$

Death-rate.—The death-rate from smallpox in England in the years 1891–95 was only 20 per million, whereas thirty years earlier it was ten times this figure; and in the period 1871–75, which included a severe epidemic, it was as high as 410 per million. In the pre-vaccination period smallpox was nine times as fatal as measles, and seven and a half times as fatal as whooping-cough (M'Vail). Now these diseases possess death-rates far exceeding that of smallpox. Germany, with a population of 54 millions, is a country where vaccination in the second year, and re-vaccination in the twelfth year of life, are compulsory, and strictly enforced. In 1899 the death-rate from smallpox was ·52 per million, and in 1897 was as low as ·09 per million. The fatal cases in 1899 occurred largely in the country, there being few in urban districts. The following table furnishes a comparison as to urban smallpox in different countries in 1899 :—

URBAN SMALLPOX (1899).

Country.	Number of Towns.	Population.	Deaths.	Death-rate per Million.	Ratio.
Germany . .	285	16,000,000 (nearly)	4	·3	1
England and Wales .	33	11,404,000	145	12·7	42
Austria . . .	58	4,000,000 (nearly)	77	20·0	67
Belgium . . .	72	2,414,000	126	52·2	174
France . . .	116	8,668,000	600	69·2	231

This table serves to show the relative thoroughness of vaccination in the urban districts of these countries.

Age Incidence of Smallpox Mortality.—Prior to 1847, when vaccination first became generally practised, smallpox was to a large extent a disease of childhood, and its greatest mortality occurred among infants and young children. Owing to the protection afforded by vaccination, children have in recent years suffered much more equally with adults, and in some years even less than older people.

There has been a steady decline in the smallpox death-rate, and the reduction has been most evident at ages under 10 years. So it came about that a greater proportion of the death-rate of smallpox occurred at ages over 10 years. The age incidence of smallpox mortality has thus been completely inverted since the introduction of vaccination. Whether this altered age incidence will still be evident in future, depends largely on the efficiency of the vaccination of the child population. There is some indication within very recent years that the large number of unvaccinated children in some parts of England may induce a return to the former age incidence of smallpox.

In recent years the deaths from smallpox at ages under 10 years have formed an increasing proportion of all smallpox deaths.

The contention that improved sanitation rather than vaccination should be credited with the whole improvement in smallpox mortality, and with the alteration in its age incidence, may be set aside for the following reasons :—

1. The great fall in the smallpox death-rate preceded the Public Health Acts ; while the similar improvement in certain other diseases only followed the enforcement of these Acts.

2. There is no proof that improved drainage and water-supply directly affect the prevalence of smallpox. They influence the occurrence of other diseases, such as enteric fever ; and inasmuch as children suffer most from

insanitary conditions, it is to be expected that improved hygiene will lessen the incidence of enteric fever on the young. But smallpox is not spread by impure water and bad drainage in the same way as enteric fever, so that, while hygienic improvements in these directions conduce to vigorous health and increase the powers of resistance to all disease, this indirect benefit would not alone account for the extensive alteration of age incidence in smallpox.

3. Those other infectious diseases which spread like smallpox, namely, whooping-cough and measles, have not shared in the altered age incidence. Deaths at ages under 5 in these diseases still maintain the same proportion to deaths at all ages, as they did in former times. Influenza is put forward as a disease the age incidence of whose mortality now compares with that of smallpox; but influenza has always been a disease of adult life, and most fatal in the aged. Only 3 per cent. of its mortality occurred at ages under 5, at the time when smallpox deaths under 5 formed about 50 per cent. of all smallpox deaths. There has been no change in its mortality among the young, as in the case of smallpox.

4. Later ages have not shared equally with children in the reduction of smallpox mortality, because the protective effect of vaccination is not absolute and lifelong. To secure immunity, re-vaccination is necessary at intervals.

5. The sanitary measures which have helped to reduce smallpox mortality are isolation of the sick and the relief of overcrowding, thus minimising the likelihood of epidemic spread. These measures have helped in recent years to produce the continued decline of the smallpox death-rate, but could not conceivably account for the altered age incidence.

6. The enormous difference in the fatality of smallpox among vaccinated and unvaccinated patients is not explainable by any theory of general sanitation as the cause.

7. There has been no alteration in the general type of the disease, which is still virulent, as evidenced by the case mortality in the unvaccinated. If there were no vaccinated people, the disease, in a susceptible and unvaccinated community, would still show a high mortality, and children under 10 would suffer most.

In a recent epidemic at Gloucester, which was a badly vaccinated community, 64·5 per cent. of the 434 deaths occurred at ages under 10 years.

Sex.—The death-rate in the two sexes is much the same, but somewhat higher in males than in females.

Season.—Smallpox mortality is greatest in winter and spring, and lowest in autumn. The curve of its seasonal incidence is thus a single wave with its crest in the early part of the year.

Typhus Fever.—1. *Case Mortality.*—This used to be about 50 per cent., but has now fallen, and is probably not more than 10 to 20 per cent.

2. *Death-rate.*—The death-rate from typhus fever has diminished in a very marked manner in the last thirty to forty years, due to the improved sanitation and conditions of life under which the population now live. The rate has fallen from 430 per million in 1869 (when typhus first appeared in the returns as distinct from typhoid) to 57 in 1871–80, 14 in 1881–90, and to 4 in 1891–95. The death-rate from typhus per 1000 is therefore now only ·004.

3. *Age.*—Typhus is rarely fatal to children, but the case mortality increases as age advances, possibly owing in part to other contributory causes, such as alcoholism, fatty degeneration, mental culture, and brain fatigue.

4. *Sex.*—Males are more liable than females to a fatal issue.

5. *Locality.*—Dirty, mean dwellings in the poorer parts of towns. Wretched country hovels, as in Ireland.

6. *Season.*—Typhus is most common in winter and cold weather. This is due to overcrowding and want of ventilation coincident with such conditions among the poorer classes.

Whooping-cough.—1. *Case Mortality.*—The average varies from 2 to 5 per cent., but must be much higher in infants.

2. *Death-rate.*—The death-rate from whooping-cough is about ·4 per 1000 of the population; in 1871–80 there were annually 512 deaths per million, but this had fallen to 450 in 1881–90, and to 398 in 1891–95. In 1899 it was 319 per million.

3. *Age.*—Whooping-cough is a highly fatal disease in young children, and especially in infants. It is one of the earliest zymotic diseases to make itself manifest in the mortality of infants, and its death-rate in the first year of life is higher than at any later age, and may reach 7000 per million. This is reduced in the second year of life, is much less in the third year, and subsequently declines rapidly. Above 10 years of age the mortality is very small.

4. *Sex.*—Whooping-cough is more fatal to females than to males at all ages, and at each group of ages.

5. *Season.*—Whooping-cough is most prevalent and most fatal in the winter months and early spring. The curve of its death-rate gradually rises in November and December, and maintains a high level until April, when it gradually falls to its lowest point in September and October.

ZYMOTIC DISEASES.

The "zymotic death-rate" is a combined death-rate caused by the seven chief communicable diseases, *i.e.* diarrhœa, diphtheria, "fever" (simple continued, typhoid, and typhus), measles, scarlet fever, smallpox, whooping-cough. This death-rate is calculated per thousand or per million of the entire population at all ages. It would be more correct if it were possible to calculate it on the population liable to the diseases mentioned. The zymotic death-rate is usually 2 to 2·5 per thousand for the whole country, but is higher in insanitary towns, and lower in places under good hygienic conditions. As an index of sanitary condition it is by no means perfect, since it includes diseases propagated under varying conditions, and not equally affected by the improved sanitation of the country. Inferences as to the healthiness of a district, and the sanitary measures required, may be drawn from the annual death-rates of the individual diseases.

NON-COMMUNICABLE DISEASES.

Cancer.—The cancer death-rate differs from most of the preceding rates in that it has steadily increased of late years, and is now twice as high as it was some fifty years ago. Fortunately there is no doubt that part, at all events, of this increased mortality is only apparent, and is due to improved certification. The deaths from "tumour" and "ill-defined diseases" have declined, and some of these have gone to swell the cancer figures. The fact that the greater increase of cancer is among males, may partly be accounted for by improved diagnosis, since cancer in males selects organs less easily examined than its favourite sites in the female. Further, the Registrar-General has, in recent years, issued letters of inquiry concerning any doubtful certificates, and this has resulted in the assignment of more deaths to the "cancer" column.

Consideration of these points, and of the experience of the Scottish Widows' Fund Assurance Society in the matter of cancer mortality, led Dr. Newsholme and Mr. King to conclude, in 1893, that there was probably no real increase in cancer mortality. The death-rate continues, however, still to rise, not only in this country, but in others, such as Australia, and the steady increase each year probably indicates a real rise in cancer mortality. The death-rate from cancer, which in 1881–90 was ·589, is now ·8 per 1000 of the population at all ages. It is very low up to 35 years of age, and proportionately high thereafter. Of all persons who reach the age of 35 years, 1 in every 21 men and 1 in every 12 women eventually die of cancer (*52nd Annual Report of the Registrar-General*).

Age.—Note the sudden rise in the cancer death-rate in both sexes after the age of 35. The decade 35–45 has a rate four or five times as high as the previous decade, and the mortality increases in later years.

Sex.—Cancer is more common among females, their death-rate in 1899 being 977 per million as compared with 672 in males. The excess is due to the greater liability of the female mammary and generative organs to the disease. The cancer death-rate of males has in recent years increased more rapidly than that of females. In comparing the cancer experience of different countries or places, remember that it is necessary to correct the rates for differences in age and sex constitution of the populations, otherwise an erroneous comparison will be obtained. Correction of these death-rates for age and sex distribution is accomplished by calculating the deaths which would have occurred in a standard population exposed to these death-rates. The standard population used is 1 million persons aged more than 25, divided proportionately into age- and sex-groups. The relative proportions are ascertained from a life table, the construction of which is explained later (p. 460).

Climate.—Cancer is more prevalent in some climates than in others, though it may be doubted whether the climate is the causa causans; other conditions probably account for differences.

There is more cancer in England than in Ireland, though the uncorrected figures show that the reverse is the case; if, however, the death-rates be corrected for age and sex constitution, the true facts are obtained.

Circulatory Diseases.—The death-rate from these diseases is increasing, and now numbers 1708 per million. The increase has occurred partly at ages below five years, but chiefly at the later ages, and may be due partly to transference from such headings as "old age." The mortality is somewhat heavier at all ages amongst females than amongst males, for though aneurism, angina, etc., cause more deaths in the latter, the former more frequently die from valvular heart disease, embolism, and vein diseases.

Convulsions.—The death-rate from convulsions is stated separately from that of nervous diseases as a whole, and shows a marked decline in recent years. From 912 per million it has fallen in the last twenty years to 568 in 1899. The rate is much higher in males than in females, the figures respectively being 653 and 487 per million in each sex.

Developmental Diseases.—This heading includes mainly the mortality from premature birth, congenital conditions, and old age. The death-rate from these diseases amounts to 1700 per million living at all ages, but the deaths from premature birth and congenital defects are better stated as a rate per 1000 births. If so stated, premature birth is found to be responsible for nearly 20 deaths per 1000 children born. The figures for the ten years 1889–98 gave an average of 18·42, but in 1899 the number was 19·97. Congenital defects cause 4 deaths per 1000 births; an average of 3·85 in the previous ten years having risen to 4·24 in 1899. Old age caused in 1899 a death-rate of 992 per million, which is in excess of the average of the previous ten years (924). There is a considerable difference in the death-rate from old age in the two sexes, females showing a considerably higher death-rate from this cause than males. Old age mortality occurs usually during the cold season of the year.

Diabetes.—The death-rate from diabetes has, for many years, been steadily rising, and in 1899 reached 86 per million. The increase is probably both real and apparent, for the rate has doubled within twenty years. The mortality from this cause is higher among males than among females, and among adults than at youthful ages; the death-rate is very high among males at ages above 45. The increased mortality is evident in both sexes and at each age-group, but the rate of increase has been much greater at the higher ages than in the prime of life, and in females as compared with males. An inverse relation has been observed between the mortality from diabetes and the amount of rainfall. Diabetes is more common in England than in Scotland, and in Scotland than in Ireland.

Dietetic Diseases.—Under this heading are included starvation, scurvy, and alcoholism, *e.g.* delirium tremens. During 1889 to 1898 the death-rate averaged 81 per million, but in 1899 rose to 103 per million. The greater proportion of the death-rate is due to alcoholism, and this in addition to deaths resulting from inebriety, which, as formerly mentioned in connection with occupational mortality, augment the returns under other headings.

Digestive Diseases.—Deaths from diseases of the digestive system include those from enteritis and gastro-enteritis and the large class of liver diseases. Sore-throat, quinsy, and teething also come under this heading. The death-rate in 1881–90 was 1104 per million, a lower figure than in the two previous decennia. Liver diseases affect the sexes almost equally, but in the aggregate have diminished to a slight extent.

Nervous Diseases.—These are responsible for a death-rate of from 1500 to 1600 per million.

Non-Specified Causes of Death.—These form a large class which may be expected to decrease with improvement in diagnosis and with greater adherence to official nomenclature in death certification. Some 4 or 5 per cent. of the total deaths from all causes are so ill-defined in the death certificates that they cannot be assigned to any other heading but the above. The Registrar-General issues letters of inquiry to medical practitioners which result in the transference of many cases to specified headings.

Respiratory Diseases.—These do not include phthisis, and the death-rate from them amounts to something slightly over 3000 per million, and is somewhat higher in males than in females. They are most fatal at the extremes of life, especially above 65 years.

Tubercular Diseases apart from Phthisis.—The total "tubercle" death-rate is about 2000 per million of the population, of which by far the larger part is due to phthisis, other tubercular diseases accounting for a rate of from 500 to 600 per million. The chief of these are tubercular meningitis and tabes mesenterica. The former affects male children under 5 much more greatly than females, and the latter has also a similar incidence. The number of deaths due to tubercle is at present diminishing.

Urinary Diseases.—These caused a death-rate of 485 per million in 1899, which is considerably above the average for the five preceding years. The mortality from acute and chronic Bright's disease is accountable for nearly the whole of this rate, and has steadily increased. This increase is proportionately greater among females than among males.

Violence.—This heading includes accident, suicide, homicide, and execution. The death-rate from violence amounts to 688 per million, of which by far the larger portion (589) is due to accident.

Its incidence is much greater upon the male sex, being nearly three times as great in males as in females. This may be due to occupational dangers in most cases, but it is curious that, even at ages under 5, accident is more common in males.

The death-rate from accident may be decreasing, that from suicide isincreasing. Suicide and accidents both occur more often in males than infemales.

Of the methods of suicide, hanging, cut throat, drowning, and poisons contribute, in this order, to its frequency. Of the poisons, carbolic acid and opium are most often used by both sexes, next in favour are prussic acid employed by males, and strychnia by females.

SUMMARY OF DEATH-RATES FROM VARIOUS IMPORTANT CAUSES, YEARS 1895 TO 1899 INCLUSIVE.

Rate per 1000 of the Population.

Cause.		Rate per 1000.
Communicable diseases.	Diarrhœa, including cholera and dysentery	·85
	Diphtheria	·27
	Enteric fever	·17
	Influenza	·29
	Measles	·42
	Phthisis	1·3
	Puerperal fever	·06
	Scarlet fever	·14
	Smallpox	·007
	Typhus fever	·001
	Whooping-cough	·35
Non-communicable diseases.	Cancer	·79
	Circulatory diseases	1·64
	Dietetic ,,	·08
	Digestive ,,	1·20
	Nervous ,, (including convulsions)	2·10
	Respiratory ,,	3·13
	Urinary ,,	·46

DECLINE OF THE DEATH-RATE.

1. The death-rate from all causes, which now amounts to 18·3 per 1000, has fallen to this figure from 22·6, which was its average for the years 1862–71. Its decline has occurred continuously since the passing of the

Public Health Acts, and is due to the attention to sanitation resulting therefrom. Not only have a large number of lives been saved annually, but many more cases of disabling sickness have been averted. For this excellent record the main credit is due to the improved hygiene which has been inaugurated.

2. It must not be forgotten, however, that part of the decline in the death-rate during recent years is due to the influence of the birth-rate, since the country is now experiencing the condition referred to previously, *i.e.* a high birth-rate in one decade, followed by a low birth-rate in the succeeding decade. This favours a low death-rate. Should the birth-rate continue low, it will eventually produce an age constitution of the population which will favour an increase in the death-rate, and this may be expected to mask the good effects of continued sanitary efforts.

3. A contributing cause to the lowered death-rate is the sex constitution of the population. Males, with their high mortality, have diminished relatively in number, so that there is a preponderance of females in the population. The female death-rate, always lower than the male, has moreover declined even more rapidly than has the male death-rate.

LIFE TABLES.

A life table is a table showing the probabilities of life and death at each age and in each sex in a stationary population, usually taken as one million, started with at birth.

A life table may be prepared from national, local, or selected mortality experience: thus it may be prepared from that of a country, of a particular district in a country, or of assurance societies, or of healthy lives.

Life tables are prepared from time to time for the purpose of ascertaining progress in healthiness and of comparing different countries or places in respect of the life prospects of their inhabitants. For their construction it is essential to know the number and ages of the living and the number and ages of the dying. The number living is usually ascertained by estimation from two census enumerations, and the number dying from the death-returns of the intercensal decade. The mortality of any one year might be exceptional, so the ten-year period is used.

The deaths at each age and in each sex being known, and the mean population at each age and in each sex having been estimated, the death-rate is known for each age and in each sex, thus—

$$\frac{\text{The annual number of deaths}}{\text{Yearly mean population}} = \text{Death-rate per unit of the population.}$$

This is called the *Central Death-rate*, because it shows the rate at which the population is dying in the centre of the year. The method of its calculation is given more in detail at p. 463. From the central death-rate the probabilities of life and of death can be calculated, and from them the construction of a life table is easy.

There are two assumptions made in the construction of a life table—(1) That persons successively attaining the various ages will suffer from the same death-rate as their predecessors have been ascertained to suffer from in the years upon which the mortality experience is based. (2) That the deaths occurring during each year of life occur at equal intervals throughout that year of life.

SPECIMEN LIFE TABLE.

Col.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.		X.
	Age.	Number Living.	Number Dying.	Probability of Living One Year.	Probability of Dying within the Year.	Population, or Years of Life Lived in each Year of Age.	Population, or Years of Life Lived in and above each Year of Age.	Number Living, or Years of Life Lived above each Year of Age.	Expectation of Life at each Age.		Central Death-rate.
Definition.	This column shows the ages from 0–105, or such lower age at which the lives started with become extinct.	*i.e.* Born or surviving at each age.	*i.e.* Number dying in each year of age.	*i.e.* Chance at each age of living a further complete year.	*i.e.* Chance at each age of dying before reaching next year of age. Actuarial "Rate of Mortality."	*i.e.* Mean number living in each year of life.	*i.e.* Aggregate number of years which all the persons attaining any age will live thereafter.	*i.e.* Sum of the number living, or years of life lived at each age, $x+1$ and upwards to the last age in the table.	*i.e.* Average number of years lived after any age by all persons attaining that age.		*i.e.* Rate at which people are dying in the centre of the year. *i.e.* Rate of mortality per unit of the population.
									Curtate.	Complete.	
Example.	30	340,783	2826	·99171	·00829	339,370	11,082,139	10,911,748	32·02	32·52	·00832
Symbols.	x	l_x	d_x	p_x	q_x	P_x, or L_x, or $\frac{1}{2}d_x+l_{x+1}$, or $\frac{1}{2}(l_x+l_{x+1})$	Q_x, or T_x, or ΣL_x	Σl_{x+1}	e_x	E_x or $\overset{\circ}{e}_x$	m_x.

Here is a representation (p. 461) of a life table, showing its different columns and their symbols. Each will be referred to more fully. Every life table does not show all these columns, but all life tables show the majority of them. The central death-rate is not generally shown in the life table, but is inserted in the diagram, so that its symbol may accompany the others, and that the distinction between it and the actuarial rate of mortality may be clearly emphasised.

Column I.—This is merely the ages included in the life table from birth to the extinction of the lives. Its symbol is x, and, when the year x is spoken of, it refers to a year of age, and not a year of time.

Column II.—The number living at each age is denoted by l, accompanied by the age thus, l_{10} = number living aged 10, l_x = number living aged x.

The number living aged 11 is obtained by multiplying l_{10} by the number indicating the probability of any person aged 10 surviving to reach age 11, this number is p_{10}, and will be found in column IV.

So l_{x+1} is obtained by multiplying the number living at age x by p_x, *i.e.* $l_{x+1} = l_x \times p_x$.

Similarly $l_x = l_{x-1} \times p_{x-1}$.

Column III.—The average number dying each year at age x is denoted by d_x. It is obtained from the death-returns.

Column IV.—The probability of a person who has attained age x living to attain the age of $x + 1$ is denoted by p_x. It can be obtained from the formula $p_x = \frac{2 - m_x}{2 + m_x}$, where m_x denotes the central death-rate per unit of the population at age x.

A more simple method of obtaining p_x from the same data is this—

$$p_x = \text{Probability of living through one year} = \frac{\text{Number of survivors at the end of the year}}{\text{Number living at the beginning of the year}},$$

i.e.

$$p_x = \frac{\text{Mean population of the year } x - \frac{1}{2} \text{ number dying during year } x}{\text{Mean population of the year } x + \frac{1}{2} \text{ number dying during year } x},$$

i.e.

$$p_x = \frac{P_x - \frac{1}{2}d_x}{P_x + \frac{1}{2}d_x}.$$

Column V.—The probability of a person who has attained age x dying during the year x of life, and not living to attain the age $x + 1$ is denoted by q_x. It can be obtained from the equation $q_x = \frac{d_x}{l_x}$,

i.e.

$$\text{The probability of dying in any one year} = \frac{\text{Number dying during the year}}{\text{Number living at the beginning of the year}}.$$

This is the actuarial "rate of mortality."

Column VI.—The mean number living in each year of life is denoted by Px, and is equal to half the sum of those living at the beginning and end of the year, *i.e.*,

$$\text{Mean population} = \frac{\text{Number living at beginning of year} + \text{number living at the end of the year}}{2},$$

or

$$P_x = \frac{l_x + l_{x+1}}{2}.$$

COLUMN VII.—The aggregate number of years of life which all the persons attaining age x will live thereafter, until all the lives are extinct, is denoted by Q_x. It is obtained by the addition of all the numbers in the P_x column, beginning with P_x, and ending with P_{x+n}, where $x+n$ is the last age in the table.

COLUMN VIII.—The number living, or the aggregate number of years of life lived at higher ages than x, is denoted by Σl_{x+1}, and is obtained by adding all the numbers in the l_x column after l_x, *i.e.* beginning with l_{x+1}, and ending with l_{x+n}, where $x+n$ is the last age in the table.

COLUMN IX.—The expectation of life at each age is the average number of years lived thereafter by persons attaining the age x. It is obtained by dividing the aggregate number of years lived thereafter by all persons attaining age x by the number of persons reaching that age.

$$\text{Expectation of life} = \frac{Q_x}{l_x} = E_x \text{ or } e^o{}_x.$$

This is termed the complete expectation of life. What is known as the curtate expectation of life, denoted by e_x, is the total number of complete years lived thereafter by l_x persons who have attained the age x divided by l_x, *i.e.* divide the sum of those living at higher ages by the number living at the beginning of the year x of life.

$$\text{Curtate expectation of life} = \frac{\Sigma l_{x+1}}{l_x} = e_x.$$

The curtate expectation of life is half a year less than the complete expectation of life. This is so because the curtate expectation of life does not allow for the time lived in the year of death. It may be only a month, or may be nearly a year; the average is half a year, under the assumption that the deaths occur at equal intervals throughout the year. $e_x + \cdot 5 = E_x$ or $e^o{}_x$.

COLUMN X.—This column does not generally appear in a life table, but is entered in the specimen table for completeness, since its calculation precedes the construction of a life table which is based on the mortality experience represented by m_x.

The central death-rate or rate of mortality, which must be carefully distinguished from the actuarial rate of mortality, is obtained from the death-returns and the population.

It is a rate per unit of the population, and

$$m_x = \frac{d_x}{P_x} = \frac{\text{The number of deaths at age } x}{\text{The number of lives at risk at age } x}.$$

It is calculated somewhat differently if x is below 5 years than if it be above 5.

Where x is above 5.

The number of deaths at age x, i.e. d_x, is ascertained from the death-returns, which give the deaths at various age-groups. The number for the year of age x is obtained from the number for the age-group containing x by the graphic method of division (p. 469).

The number of lives at risk at age x is ascertained by estimation from two census enumerations of the number living in the age-group containing x.

First calculate the central population of the group in each of the two census years. Then the central population at the later census minus the central population at the earlier census yields a result which, divided by the annual increase per unit of the population, gives the total number of lives at risk at the age-group containing x. These can be divided up among the individual years by the graphic method (p. 469), or alternatively, by the method of finite differences.

Where x is below 5.

The death-returns yield the deaths in the same way as formerly, but special methods are required to estimate population. It is not necessary here to go into further detail, for which the reader is recommended to consult Newsholme's excellent work on "Vital Statistics."

m_x having been ascertained, p_x is obtained from it by the formula—

$$p_x = \frac{2 - m_x}{2 + m_x}.$$

Having ascertained p_x for each age and in each sex, the life table can be prepared. It is usual to start with a given number, usually 1 million, either 1 million of each sex, or 1 million divided between the sexes in the proportion between the sexes at birth, as found to exist at the last census. The example in the specimen life table (p. 461) is taken from the English Life Table (1881–90), in which the population started with was 1,000,000, divided between the sexes in the proportion of 509,180 males to 490,820 females. The figures refer to males aged 30.

Suppose we begin with 1,000,000 males at birth, then place 1,000,000 in the column l_x opposite the age 0. To find the number of those who would reach age 1, multiply 1,000,000 by p_o, as found for males, and get a figure, which is placed in column l_x opposite age 1.

To find the number aged 2, multiply the figure l_1 by p_1, and so on throughout the ages until the million lives are extinct.

THE LENGTH OR DURATION OF LIFE.

The length of life of individuals composing communities has been calculated with a view to comparing the vitality and healthiness of separate countries, classes, or places.

The duration of life may be estimated by finding out the following :—(1) The mean age at death ; (2) the expectation of life ; (3) the number living out of which one dies annually ; (4) the probable duration of life ; (5) the mean duration of life.

1. *The Mean Age at Death.*—The mean age at death, say of this country, is the sum of the ages of the inhabitants of the country at their death divided by the number of deaths.

2. *The Expectation of Life or Mean After-Lifetime.*—This is ascertained from a life table, and, as explained (p. 463), is the average number of years lived after any age by all the persons who reach that age. For example, from the knowledge obtained from a certain life table, males reaching age 30 may expect to live a further 32·5 years, but every individual aged 30 will not live exactly 32·5 years ; some will live more, and some less. Hence the term expectation of life has no relation to the length of life which any individual will probably live.

Besides the life-table method of calculating expectation of life, there are two other methods, those of Farr and Willich, but these are not so good.

Farr's formula for calculating the expectation of life at birth from the known death- and birth-rates is $\left(\frac{2}{3}\times\frac{1}{d}\right)+\left(\frac{1}{3}\times\frac{1}{b}\right)=$ expectation of life at birth.

Note that d and b are death- and birth-rates per unit of population.

Willich's formula is fairly correct for ages between 25 and 75, but not for the extremes of life.

It is that the expectation of life $=\frac{2}{3}(80-x)$, where $x=$ present age.

3. *Number Living, out of which one dies annually.*—This is ascertained by dividing the number of the population by the number of deaths occurring in one year. By De Moivre's hypothesis, 1 person in 86 was supposed to die annually; this figure is erroneous in youth and old age, and not quite accurate even at intermediate ages.

4. *The probable Duration of Life.*—This is the number of years in which any number of children, all born at one time, will be reduced to exactly one-half. The chance of living less or more than that particular number of years is the same for each child.

5. *Mean Duration of Life.*—This is not a good term, and its signification has been confused. It should be only another expression for mean after-lifetime or expectation of life. Actuarially it sometimes means "present age added to expectation of life."

COMPARISON OF COMMUNITIES AS TO DURATION OF LIFE.

The best method of comparison is by means of life tables, and the expectations of life for groups of people at various ages therein revealed. If this method is not available, a comparison of the deaths at each age-group in proportion to the number living in the same age-group may be usefully employed.

The mean age at death is not a good means of comparison, owing to the differences in age constitution depending on variations in the birth-rate and in migration. From these causes England shows a low mean age at death combined with a high expectation of life at birth and with a low mortality.

The mean age of the living is no better test of the duration of life than is the mean age at death. The mean age of the living

$$=\frac{\text{The sum of the ages of the population at census}}{\text{Number of population}}.$$

ENGLISH EXPECTATION OF LIFE.

The expectation of life at birth has increased in both sexes; comparing 1881–90 with 1871–80, the male has risen from 41·35 to 43·66 years, and the female from 44·62 to 47·18 years.

This means that the death-rate at early ages being lower, more people survive to the working ages, and the aggregate life of the whole community is greater at the most useful years. The expectation of life at ages over 45 was less in 1881–90 than in 1871–80, owing to more persons having survived that age without a corresponding increase in the years of life lived at the higher ages.

EXCERPT OF ENGLISH LIFE TABLES.

1871–80 (OGLE) AND 1881–90 (TATHAM).

Age.	Males.				Females.			
	Survivors at each Age out of 1,000,000 born.		Expectation of Life.		Survivors at each Age out of 1,000,000 born.		Expectation of Life.	
	1871–80.	1881–90.	1871–80.	1881–90.	1871–80.	1881–90.	1871–80.	1881–90.
0	1,000,000	1,000,000	41·35	43·66	1,000,000	1,000,000	44·62	47·18
1	841,417	838,964	48·05	50·97	871,266	868,874	50·14	53·24
5	734,068	751,494	50·87	52·75	762,622	783,244	53·08	54·92
10	708,990	733,477	47·60	49·00	738,382	766,151	49·76	51·10
15	696,419	726,194	43·41	44·47	724,956	759,062	45·63	46·55
20	680,033	712,555	39·40	40·27	707,949	744,321	41·66	42·42
25	657,077	693,809	35·68	36·28	684,858	724,788	37·98	38·50
30	630,038	669,279	32·10	32·52	658,418	700,049	34·41	34·76
35	598,860	639,645	28·64	28·91	628,842	670,992	30·90	31·16
40	563,077	604,923	25·30	25·42	596,113	638,912	27·46	27·60
45	522,374	564,437	22·07	22·06	560,174	604,007	24·06	24·05
50	476,980	517,639	18·93	18·82	520,901	564,299	20·68	20·56
55	424,677	462,981	15·95	15·74	477,440	516,375	17·33	17·23
60	365,011	398,400	13·14	12·88	422,835	457,682	14·24	14·10
65	297,156	322,482	10·55	10·31	356,165	385,503	11·42	11·26
70	222,056	238,632	8·27	8·04	277,225	299,220	8·95	8·77
75	144,960	153,890	6·34	6·10	190,566	204,208	6·87	6·68
80	77,354	80,023	4·79	4·52	108,935	114,536	5·20	5·00
85	30,785	29,866	3·56	3·29	47,631	48,133	3·88	3·71
90	8,015	6,786	2·66	2·37	14,225	13,148	2·90	2·75
95	1,183	752	2·01	1·72	2,533	2,124	2·17	2·05
100	82	30	1·61	1·24	225	157	1·62	1·54

The expectation of life at any age in the table may be calculated by adding together the years of life lived through by the life-table population after that age, and dividing by the number of survivors at that age. In such a table as the above, where quinquennia only are given, the years must be obtained by multiplication by 5. It is necessary to add as many half-quinquennia as there are survivors, so as to allow for the portion of the quinquennium lived through in the quinquennium in which death occurs.

The years of life lived between the ages 25–55, *i.e.* in the best working period of life, amounts to about 40 per cent. of the total lifetime of the population.

LIFE CAPITAL.

The life capital of a community is the sum of the products obtained by multiplying the population of each age-group by the mean expectation of life for that age-group.

Each unit of the population possesses—(1) A life capital, which is his future lifetime; and (2) an average life capital. This is the quotient obtained by dividing the life capital of the community by the number of the population. The average future lifetime of each individual in the community

$$= \frac{\text{Life capital of the community}}{\text{Population}}.$$

In order to ascertain what proportion of its life capital a community is spending in a year, it is necessary to remember that the mean population of the year represents the years of life expended in that year, so that—

$$\frac{\text{Mean population} \times 100}{\text{Life capital}} = \text{Percentage of life capital used up in the year.}$$

If the deaths in any year are less than would have occurred had the death-rate maintained its former level, there is a gain to the community of so many lives and of so much life capital.

MEANS AND AVERAGES.

There are four mathematical means, the arithmetic, geometric, harmonic, and quadratic means. Let x, y, and z be the terms of which the mean is desired.

$$\text{Then (1) Arithmetic} = \frac{x+y+z}{3}.$$

$$\text{(2) Geometric} = \sqrt[3]{xyz}.$$

$$\text{(3) Harmonic} = \frac{3}{\frac{1}{x}+\frac{1}{y}+\frac{1}{z}}.$$

$$\text{(4) Quadratic} = \sqrt{\frac{x^2+y^2+z^2}{3}}.$$

Of these the arithmetical mean is the one most often used in vital statistics. If the series of which the mean is desired be composed of equal terms, then the means are also equal; but if the terms are unequal, the quadratic mean is the highest, then the arithmetic, geometric, and harmonic in order.

What is termed the *error of mean square* is

$$= \frac{\text{Quadratic mean} - \text{arithmetic mean}}{n^2 - n},$$

where n is the number of terms in the series of which the means are taken.

Series.—The value of a series of observations increases with the number of observations, since the error diminishes and the accuracy increases the greater the number of observations.

The relative values of two or more series vary directly as the square roots of the numbers of observations included in each series.

The *limit of possible error* is smaller, the larger the number of observations. Suppose that the number of observations recorded deals with x cases, and that the observations are divisible into the two classes y and z, *e.g.* deaths and recoveries, so that $y+z=x$.

Then the proportions of y to x and of z to x will be represented by the fractions $\frac{y}{x}$ and $\frac{z}{x}$.

The possible variations in the proportions of y to x occurring in different series of x cases is represented by Poisson's formula as being within the following values—

$$\frac{y}{x} + 2\sqrt{\frac{2yz}{x^3}} \text{ and } \frac{y}{x} - 2\sqrt{\frac{2yz}{x^3}}.$$

Consideration of this formula shows that the larger x is, the smaller the value of the quantity $2\sqrt{\frac{2yz}{x^3}}$, and the less, therefore, the variation in the value of $\frac{y}{x}$ as observed in different series of x cases.

The same formula may be applied to the variations in the value of $\frac{z}{x}$ in different series of x cases.

The larger the number of observations from which deductions are made, the smaller is the limit of possible error.

The *mean error of a series* is the mean or average of the errors in excess and in deficiency, and is equal to

$$\frac{\text{Mean error in excess} + \text{mean error in deficiency}}{2}.$$

The *mean error in excess of a series* is the average amount by which the terms of a series which are higher than the mean of the series exceed that mean.

The *mean error in deficiency of a series* is the average amount by which the terms of a series which are lower than the mean of the series fall short of that mean.

For example, take the series of numbers 1, 3, 5, 8, 10, 17, 31—

The arithmetic mean of the series $= \frac{1+3+5+8+10+17+31}{7} = \frac{75}{7} = 10{\cdot}7.$

The mean error in excess is thus obtained—

$$\begin{aligned} 31 - 10{\cdot}7 &= 20{\cdot}3 \\ 17 - 10{\cdot}7 &= 6{\cdot}3 \\ \hline & 26{\cdot}6 \end{aligned}$$

and $\frac{26{\cdot}6}{2} = 13{\cdot}3 =$ mean error in excess.

The mean error in deficiency is similarly obtained—

$$\begin{aligned} 10{\cdot}7 - 1 &= 9{\cdot}7 \\ 10{\cdot}7 - 3 &= 7{\cdot}7 \\ 10{\cdot}7 - 5 &= 5{\cdot}7 \\ 10{\cdot}7 - 8 &= 2{\cdot}7 \\ 10{\cdot}7 - 10 &= {\cdot}7 \\ \hline & 26{\cdot}5 \end{aligned}$$

and $\frac{26{\cdot}5}{5} = 5{\cdot}3 =$ mean error in deficiency.

The *mean error of the series* 1, 3, 5, 8, 10, 17, 31 is therefore $= \frac{13{\cdot}3 + 5{\cdot}3}{2} = \frac{18{\cdot}6}{2} = 9{\cdot}3.$

The *probable error of a series* is the mean error of the series multiplied by ·67449 or $\frac{2}{3}$.

In the above series it would be 6·2, for $9{\cdot}3 \times {\cdot}67449$ or $9{\cdot}3 \times \frac{2}{3} = 6{\cdot}2$.

Paucity of data.—Accuracy of deduction increases as the square root of the number of observations from which deductions are made. Inaccuracy is frequently the result of an insufficient number of observations.

Errors in statistics from paucity of data are very numerous: *e.g.*, if of two cases of a particular disease one die, there is an apparent case mortality of 50 per cent.; but it would be grossly erroneous to assume from this that the case mortality of the disease is 50 per cent. The real case mortality is probably very much less, and investigation of a large number of cases would give a more accurate result.

Ratios.—A common error in statistics, and one to be carefully avoided, is the composition of ratios, that is, taking an average of rates, such as death-rates, etc. Rates must not be compounded by taking their arithmetical mean as a rate of the combined areas, populations, or whatever it may be to which they refer. This will be best comprehended by an illustration. If a town of 180,000 inhabitants have a death-rate of 18 per 1000, and an adjacent district have a population of 20,000 and a death-rate of 15 per 1000, the death-rate of the whole area must not be stated as $\frac{18+15}{2}=\frac{33}{2}=16{\cdot}5$.

The death-rate of the whole area is obtained thus—

180,000	inhabitants at 18 per 1000 yield	$18\times18=$	3240	deaths per year.
20,000	,, ,, 15 ,, ,,	$20\times15=$	300	,,
200,000	,, ,,		3540	,,

If 3540 deaths occur in a year in a population of 200,000, the death-rate per 1000 is $\frac{3540\times1000}{200,000}=17{\cdot}7$.

There is an enormous difference between a death-rate of 16·5 and one of 17·7, so that the error would in this case be very serious. It is important to remember that rates must be calculated and not compounded.

GRAPHIC METHOD.

This is a method for mechanical division of numbers, and may be used in assigning to each component of a group the share it possesses in the whole group. For this purpose it is useful in the construction of a life table, in dividing the population of an age-group into the respective numbers at each age, or in distributing the deaths of an age-group over its component ages. The method will be most easily understood from a consideration of the accompanying diagram (Fig. 189), which shows the distribution at the various ages of a life-table population of males, commencing with 1 million at birth. The diagram is constructed by setting off on an abscissa line, *xy*, five equal portions, each representing five years of life, and assigned to the first five quinquennial periods of life. Next set off eight other portions, each equal to double the length assigned to the quinquennial divisions. These represent subsequent decennial intervals of age. On this abscissa erect perpendiculars at points corresponding to the age intervals, and draw these to scale, so that parallelograms may be formed, having as a basis abscissal intervals, and as sides the perpendiculars. The area of any parallelogram corresponds to the number of lives at risk in the quinquennial or decennial period to which the parallelogram is applied. A curved line is drawn through the parallelograms from the commencement of the second quinquennium to the last age plotted on *xy*. This curve must be as straight as possible, must not be interrupted by abrupt changes of direction, and must so cut each parallelogram that the area excluded by the curve is equal to the area bounded by the curved line, the top of the parallelogram, and a portion of the side of the

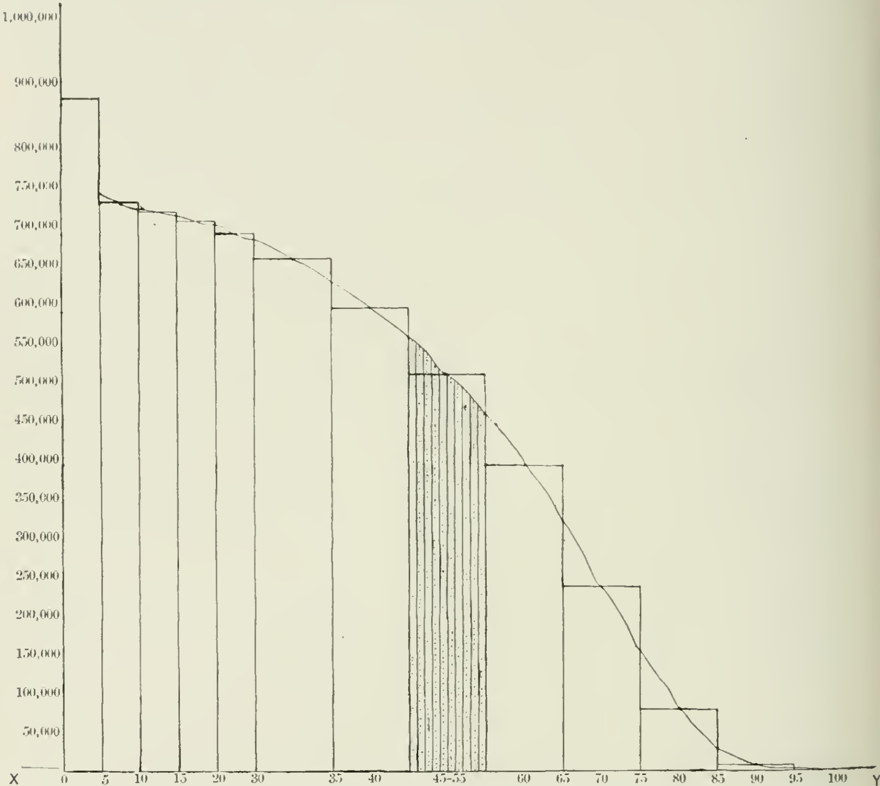


Fig. 189.—Graphic method of division into components.

antecedent and adjacent parallelogram. To find the number living at any age, *e.g.* 47, divide the decennial parallelogram by perpendiculars at equal intervals, so as to represent each year of age, and continue these perpendiculars upwards until they meet the curved line. In the space allotted to the age 47 dot in a central line perpendicular to the abscissa, and continue it up to the curved line; its height on the scale will then represent the population living at the centre of the year 47 of age.

The graphic method is also used for the graduation of any irregular curve so as to smooth out accidental irregularities, due, *e.g.*, to paucity of observations. The actual observed values are delineated on a graduated paper, and a smooth curve drawn by hand as near them as possible and without sharp changes of direction. Comparison is then made between the amended and the observed values so as to secure a fair graduation.

SANITARY ADMINISTRATION AND SANITARY LAW.

ABBREVIATIONS.

AUTHORITIES.

B. of A.	= Board of Agriculture.
C.C.	= County Council.
D.C.	= District Committee (in Scotland).
,,	= District Council (in England).
L.A.	= Local Authority.
L.As.	= Local Authorities.
L.C.C.	= London County Council.
L.G.B.	= Local Government Board.
P.C.	= Parish Council.
P.L.A.	= Port Local Authority.
P.S.A.	= Port Sanitary Authority.
R.A.	= Rural Authority.
R.D.C.	= Rural District Council.
R.S.A.	= Rural Sanitary Authority.
S.A.	= Sanitary Authority.
S.As.	= Sanitary Authorities.
U.A.	= Urban Authority.
U.D.C.	= Urban District Council.
U.S.A.	= Urban Sanitary Authority.

OFFICIALS.

I.C.L.H.	= Inspector of Common Lodging Houses.
I.N.	= Inspector of Nuisances.
M.O.	= Medical Officer.
M.O.H.	= Medical Officer of Health.
S.I.	= Sanitary Inspector.
S.S.	= Sanitary Sub-officer.

MISCELLANEOUS.

C.L.H.	= Common Lodging House.
P.H.	= Public Health.
R.D.	= Rural District.
R.S.D.	= Rural Sanitary District.
U.D.	= Urban District.
U.S.D.	= Urban Sanitary District.

ACTS.

A.W.R.A.	= Alkali Works Regulation Act.
A.W.R.A.A.A.	= Alkali Works Regulation Act Amendment Act.
B.G.A.	= Burial Grounds Act.
B.G.(S.)A.	= Burial Grounds (Scotland) Act.
B.P.(S.)A.	= Burgh Police (Scotland) Act.
B.W.A.	= Barbed Wire Act.
C.D.(A.)A.	= Contagious Diseases (Animals) Act.
C.L.H.A.	= Common Lodging Houses Act.
C.M.R.A.	= Coal Mines Regulation Act.
D.(A.)A.	= Diseases (Animals) Act.
D.B.G.A.	= Disused Burial Grounds Act.
D.C.M.O.	= Dairies, Cow-sheds, and Milk-shops Orders.
F.&W.A.	= Factories and Workshops Act.
H.W.C.A.	= Housing of the Working Classes Act.
I.D.N.A.	= Infectious Diseases Notification Act.
I.D.P.A.	= Infectious Diseases Prevention Act.
I.H.A.	= Isolation Hospitals Act.
L.G.A.	= Local Government Act.
L.G.(S.)A.	= Local Government (Scotland) Act.
M.A.	= Margarine Act.
M.F.F.C.A.	= Markets. Fairs, and Fairs Clauses Act.
P.H.A.	= Public Health Act.
P.H.A.A.A.	= Public Health Act Amendment Act.
P.H.(I.)A.	= Public Health (Ireland) Act.
P.H.(Int.)A.	= Public Health (Interments) Act.
P.H.(L.)A.	= Public Health (London) Act.

P.H.(S.)A.	= Public Health (Scotland) Act.
Q.F.A.	= Quarry Fencing Act.
R.P.P.A. . . .	= Rivers Pollution Prevention Act.
S.F.D.A. . . .	= Sale of Food and Drugs Act.
S.F.D.A.A.A. . .	= Sale of Food and Drugs Act Amendment Act.
T.I.A.. . . .	= Towns Improvement Act.
T.I.C.A. . . .	= Towns Improvement Clauses Act.

SANITARY ADMINISTRATION.

THE sanitary administration of the country is bound up with the system of local government, and varies in the different kingdoms.

ENGLAND AND WALES.

The care of the Public Health in England and Wales is primarily under the Local Government Board, which was established in 1871, and consists of a President, appointed by the Crown, and certain *ex-officio* members, namely, the Lord-President of the Privy Council, all the Principal Secretaries of State, the Lord-Privy Seal, and the Chancellor of the Exchequer. To the L.G.B. is delegated the charge of local government, public health, registration of births, marriages, and deaths, drainage and sanitary matters, public improvements, baths, wash-houses, artisans' and labourers' dwellings, local taxation, the prevention of disease, and vaccination.

These duties were formerly discharged by the Secretary of State, the Privy Council, and the Poor Law Board.

The L.G.B. discharges its duties in regard to the P.H. by means of a staff of medical officers, inspectors, and laboratory experts, and takes cognisance of disease in all parts of the country, and the component sanitary areas into which it is divided under the control of local authorities.

The L.G.A. of 1894 divides the country into—(*a*) *Administrative Counties*, in which the local authority for P.H. purposes is the County Council, and these are further divided into—(1) Urban, (2) Rural, Sanitary Districts, in which the local authority is the District Council, urban and rural respectively. Rural sanitary districts are further subdivided into parishes, in which the Parish Council forms the local authority. (*b*) *County Boroughs*, in which the local authority is the Town Council. (*c*) *Municipal Boroughs*, in which the Municipal Council is the L.A. (*d*) The L.G.A. does not apply to London, which is constituted the County of London Metropolitan Borough, and has for its L.As. the L.C.C. and the Metropolitan Borough Councils. (*e*) The only other S.A. in the kingdom is termed a P.S.A., which has jurisdiction over a port and its vessels, waters, and persons, and is constituted by an order of the L.G.B. under the P.H.A., 1875. The order may constitute a P.S.A. as a permanent or temporary body. The L.G.B. may combine one or more L.As. in the P.S.A.

The respective powers or duties connected with public health of these L.As. are :—

A. COUNTY COUNCIL.

1. Supervision of L.As. within its district.
2. Prevention of pollution of rivers.
3. Delimitation of hospital districts. Lending money for the erection of isolation hospitals.

4. Making of By-laws
- (a) for supervision and administration of the county: to be confirmed by a Secretary of State.
- (b) for prevention and supervision of nuisances: to be confirmed by the L.G.B.

5. Appointment of M.O.H. for county.
6. Appointment of analysts.
7. To receive reports from M.O.H. (county) and M.O.H. (district).
8. To contribute to salaries of staff in districts under their supervision.
9. To report to L.G.B. on any matter relating to P.H.
10. To act as appeal authorities to whom P.C. may appeal against R.S.A.
11. To acquire lands for allotments.
12. To administer the D.(A.)A.
13. To arrange for county M.O.H also acting as district M.O.H.
14. To pay half the salary of M.O.H. of every L.A. for any area of the county.

I. URBAN DISTRICT COUNCIL.

1. To administer the following Acts:—P.H.A., 1875; P.H.A.A.A., 1890 (adoptive); P.H. (Water) A., 1878, if applied by L.G.B.; Rivers Pollution Prevention Acts, 1876, '93; F.&W.A., 1901 (sanitary provisions); H.W.C.A., 1890, '99; I.D.N.A., 1889, '99; I.D.P.A., 1890 (adoptive); S.F.&D.A., 1875, '79, and '99; Horseflesh Act, 1889; M.A., 1889; D.C.M.O., 1885–86 and '99; P.H.(Int.)A., 1879; Canal Boats Act, 1877, '84; Cleansing of Persons Act, 1897; Local Sanitary Acts; Infant Life Protection Act, 1897.
2. To appoint M.O.H., surveyor, and inspector of nuisances.
3. To delegate powers to committees of their numbers.
4. Powers to adopt adoptive Sanitary Acts.
5. To license and control knackers' yards.
6. To apply to L.G.B. for investiture with powers of Parish Councils.

II. RURAL DISTRICT COUNCIL.

1. To administer the same Acts as mentioned under Urban District Councils, but with restricted powers as regards certain clauses of the Public Health and Housing Acts. The administration of the P.H.(Water)A., 1878, which specially applies to rural districts.
2. To hold land for the purposes of their powers.
3. To apply to L.G.B. for investiture with the powers of U.D.C.
4. To license and control knackers' yards.
5. To appoint Parochial Committees for outlying parishes.
6. To delegate certain powers to Parish Councils.

III. PARISH COUNCILS.

These are created by the L.G.A., 1894, in every parish having a larger population than 300 persons. They may be created in parishes with less than this population by resolution of a "Parish Meeting" and an order from the C.C. More than one parish may be governed by one Parish Council, provided the Parish Meeting of each parish approve and the C.C. agree.

Duties.

1. Parish Councils are empowered to attend to such sanitary matters as the utilisation of wells, springs, and streams in the parish, the drainage, or remedying of ponds and stagnant pools, the acquisition or hiring of land for allotments, and procedure connected with allotments, the necessary application to the M.O.H. under the H.W.C.A., recreation grounds, and open spaces.

2. To apply to the L.G.B. for powers of U.D.C.

3. To appeal to the C.C. if the R.D.C. fail in any duty regarding the parish.

4. To raise money on loan, only with the approval of the C.C., L.G.B., and Parish Meeting.

IV. PAROCHIAL COMMITTEES.

These derive their powers from the R.D.C., by whom they are appointed, and supervise in their parish such matters as—

1. Periodic inspection of parish as to the constructive works necessary, and superintendence of the execution of such works.

2. Nuisances, their detection, investigation, and notification.

3. Auditing of expenditure within their district.

4. Reporting to R.D.C. on any matters connected with the P.H. of the district.

B. COUNTY BOROUGHS.

Town Council.—These possess the same powers as U.D.C.

C. MUNICIPAL BOROUGHS.

Municipal Council.—These possess the same powers as U.D.C.

D. LONDON.

The L.C.C. and Metropolitan Borough Councils.—In the City of London the *Commissioners of Sewers.* The P.H.A., 1875, does not wholly apply to London, but the S.As. of London possess powers under certain of its clauses, and, in addition, under special Acts, *e.g.* P.H.(London)A., 1891, etc.

E. PORTS.

Port Sanitary Authorities.—Their powers are derived from the L.G.B., and are stated in the Order constituting the authority. The powers are regulated by the following Acts :—The P.H.A., 1875 ; the P.H.(Ships)A., 1885 ; P.H.(Ports)A., 1896 ; P.H.A., 1896. The L.G.B. confers upon a P.S.A. much the same powers as an U.S.A. possesses under the P.H.Acts and the I.D.P.A. In addition, the P.S.A. possess powers under the Regulations of the L.G.B. as to cholera, yellow fever, and plague, importation of rags, etc. The P.S.A. of London is the Corporation of London. The P.S.A. must appoint a M.O.H. and I.N.

IRELAND.

For P.H. purposes, Ireland is divided into urban and rural sanitary districts under the L.G.B. for Ireland. The S.A. in the U.S.D. is the Corporation or

Town Commissioners; in the R.S.D., the Board of Guardians. The powers of the S.A. are exercised under the P.H.(I.)A., 1878, '90, and '96, and under special Acts, such as the T.I.C.A., 1847, and the T.I.A., 1854. The P.H.(I.)A., 1878, is modelled on the English P.H.A., 1875. U.S.A. may delegate their powers to committees. R.S.As. have not this power. The L.G.B., by Provisional Order confirmed by Parliament, may on the petition of any town or district alter the S.A. by constituting a town in a rural district a separate U.S.A., or including it in an adjacent urban district, or adding an U.S.D. to the R.S.D. in which it lies.

SCOTLAND.

The L.G.B. for Scotland consists of the Secretary for Scotland, who is President, the Under-Secretary for Scotland, the Solicitor-General for Scotland, the Vice-President of the L.G.B., and two members belonging respectively to the legal and medical professions. The first three are members of the Government, and ex-officio members of the Board. The last three are appointed members, and are permanent officials. The L.G.B., as the central authority, superintends the P.H. of the whole country on the advice of the medical member of the Board, who is assisted in the necessary investigations by a medical inspector.

The L.G.(S.)As. of 1889 and 1894 divide Scotland into districts, and the local authorities are as follows:—

LOCAL AUTHORITIES.

Constitution.—(*a*) In burghs subject to the B.P.(S.)A., 1892, *Town Council* or *Burgh Commissioners.*

(*b*) In other burghs, *Town Council* or *Board of Police.*

(*c*) In districts where the county is divided into districts under the L.G.A., 1889, and subject to sec. 17 of that Act, as amended by the P.H.A., 1897, the *District Committee*, exclusive of those of its members who sit as representatives of burghs. Each parish is entitled to elect a Parish Council, and also to elect one county councillor; and each Parish Council is entitled to send a representative to the District Committee, and each county councillor is entitled to a place on a District Committee.

(*d*) In counties not so subdivided, the *County Council*, exclusive of members who sit as representatives of burghs.

Counties are divided into districts, and the councillors for the district, together with one representative of the Parish Council of each parish in the district, make up what is called the *District Committee of the C.C.*, and this body is the L.A.

The only other S.A. is the P.S.A., which may be created for any port district by the L.G.B. constituting one or more L.As. as the P.S.A.

The general powers and duties of these L.As. are—

1. To hold land for P.H. purposes.

2. To appoint committees to receive and issue notices, to take proceedings, and to execute Acts.

3. To empower any person to serve notices, make complaints, or take proceedings on their behalf.

4. To appoint a M.O.H. and S.I. The latter is also I.C.L.H.

5. Subject to the L.G.B. to regulate the duties of the M.O.H. and S.I., pay them proper salaries, and to report such appointment and salaries to the L.G.B.

6. To report to the L.G.B. when required by the L.G.B.

7. To authorise the M.O.H. to exercise any powers with which the S.I. is invested by the P.H.A.

8. To pay the registrar for returns of births and deaths, to provide forms for such returns, and to pay their postage.

9. To approve temporary substitutes for the M.O.H. and S.I. in case of illness or authorised absence, or to withdraw, with the consent of the L.G.B., such approval.

10. To administer the P.H.(S.)A., 1897, and various earlier P.H. Acts and Amendment Acts in so far as these have not been repealed, the I.D.N.A., R.P.P.A., F.&W.A., 1901; B.P.(S.)A., 1892: in part, D.(A.)A., 1878, '86, and '94; H.W.C.A., 1890, '99; S.F.D.A., 1875, '79, and '99; Horseflesh Act, 1899; M.A., 1887; B.G.(S.)A., 1855; Cleansing of Persons Act, 1897; and Infant Life Protection Act, 1897.

While these are the general powers, certain of them only appertain to certain local authorities. To the C.C. is entrusted the charge of prevention of river pollution, and appointment of the M.O.H. and S.I. The powers of rating, borrowing, acquiring, or holding land belong to the C.C., but are exercised by the C.C. exclusive of those representatives from Parish Councils who in places under sec. (*d*) are associated in the C.C. as L.A. The C.C. can do nothing requiring expenditure of large capital sums without the sanction of the *Standing Joint Committee*. The D.C. has no power of raising money by rate or loan, or of holding land. It is subject to the general regulations of the C.C., and any proceedings and orders of the D.C., save those for removal of nuisances, are subject to review by the C.C. on appeal of five ratepayers. The D.C. cannot appoint the M.O.H. and S.I.

EXECUTIVE OFFICERS.

Officials.—The officials of the L.As. for P.H. purposes are in England and Wales, the M.O.H., Surveyor, and I.N.; in Ireland, the M.O.H. and the S.Ss.; in Scotland, the M.O.H. and S.I.

They are appointed in England under the P.H.A., 1875; in London, the P.H.A., 1891; in Ireland, the P.H.(I.)A., 1878; and in Scotland, the P.H.(S.)A., 1897, and the B.P.(S.)A., 1892. In England the C.C. is authorised to appoint a county M.O.H., who must give his whole time to the duties of his office, unless the C.C. otherwise assent; the U.S.A. must appoint a M.O.H., a Surveyor, and an I.N.; the R.S.A. must appoint a M.O.H. and I.N. Two or more S.As. may appoint the same M.O.H. or I.N., and the L.G.B. may compulsorily unite districts for this purpose.

If any part of the salary of a M.O.H. is repaid to a L.A. out of Imperial funds, the L.G.B. has the same powers in regard to qualification, appointment, duties, salary, and tenure of office as it has in the case of a poor-law medical officer. In *London* every S.A. must appoint one or more M.O.H. for its district, and a sufficient staff of I.N. Two or more S.As. may unite to appoint one M.O.H. if the L.G.B. consent. A London M.O.H. may exercise the powers of an I.N., and must reside in or near his district.

In *Ireland* the dispensary medical officers are *ex-officio* M.O.H. for their districts, and, in addition, the L.G.B. may require the appointment of a consulting M.O.H. and the appointment of sufficient S.Ss. The S.A. may, in addition, appoint a surveyor, but S.As. may not combine for the appointment of sanitary officers. Half the salaries are paid from Imperial funds.

In *Scotland* the L.A. must appoint a M.O.H. and one or more S.I., who are also *ex-officio* I.C.L.H.; must supply them with officers and clerks, and report the names, addresses, and salaries to the L.G.B. The M.O.H. may exercise any of the powers of a S.I. if authorised by the L.A. to do so.

Qualifications.—The qualifications required of the M.O.H. are—In *England and Wales* the M.O.H. must be a legally qualified medical man, and, if appointed after January 1, 1892, to a district having 50,000 inhabitants or more, must also be registered as holding a degree or diploma in P.H., or have for three years been M.O.H. of a district of more than 20,000 inhabitants, or have been for three years a M.O. or Inspector of the L.G.B.

The I.N. or S.I. appointed after January 1, 1895, must be the holder of a certificate of such body as the L.G.B. may approve (London, Conjoint Board; Provinces, Sanitary Institute), or, failing this, must have been during three consecutive years I.N. or S.I. of an district in London or of an U.S.D. out of London containing, according to the last census, a population of not less than 20,000. The qualifications required of an I.N. in the provinces have not been prescribed.

In *Scotland*, under the L.G.A., 1889, the M.O.H. must be a registered medical practitioner, and may not be appointed for a county, district, or parish with a population of 30,000 or upwards unless he holds a diploma in P.H. In burghs the B.P.(S.)A., 1892, requires that the M.O.H. shall be a registered medical practitioner, and, if appointed after May 15, 1894, he must also hold a qualification in P.H. The S.I. of a county must have been S.I. to a L.A. for the three consecutive years prior to his appointment.

Tenure.—In *England and Wales*, if any part of the salary of the M.O.H. is repaid out of Imperial funds, the consent of the L.G.B. is required to the terms of tenure of his office, and he can only be removed by the L.G.B., or by the S.A. with consent of the L.G.B. The S.A. may suspend him from office, but the L.G.B. can remove that suspension. If no part of the salary of the M.O.H. is so repaid, the L.G.B. has no control over his tenure of office. The tenure of the M.O.H. in *London* is similar to that of a M.O.H. in the provinces to whose salary a contribution is made from Imperial funds; but his appointment cannot be made for a limited period, as is the case outside London. In *Ireland* the tenure of office of the M.O.H. and S.S. is such as the S.A., with consent of the L.G.B., may decide. In *Scotland* the M.O.H. or S.I. of any county, district, or burgh cannot be removed from office without the consent of the L.G.B.

Duties.—The duties performed by the M.O.H. and sanitary officials are similar in the three kingdoms. The duties of M.O.H., as prescribed by the L.G.B., are the same, whether a contribution is made to the salary or not, except that in the latter case the officer is obliged to report his appointment within seven days to the L.G.B.

"A copy of the annual report and of every special report must be sent to the L.G.B. whether there is any repayment of salary or not; but there is no compulsion in this respect as regards medical officers of health appointed prior to March 1880, if no repayment of salary is claimed by the authority.

"County councils are entitled to receive a copy of all annual and other reports which the medical officer of health of any district within the county is required to send to the L.G.B., and, in default, may refuse to pay any contribution to his salary which otherwise they would be liable to pay."

The following duties are prescribed by the Board's Order of March 1891, for every M.O.H. appointed or reappointed after that date:—

"1. He shall inform himself, as far as practicable, respecting all influences affecting, or threatening to affect, injuriously the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal, the cause, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall, by inspection of the district, both systematically at certain periods and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the S.A. on all matters affecting the health of the district, and on all sanitary points involved in the action of the S.A.; and in cases requiring it he shall certify for the guidance of the S.A., or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

"5. He shall advise the S.A. on any question relating to health involved in the framing and subsequent working of such by-laws and regulations as they may have power to make, and as to the adoption by the S.A. of the I.D.P.A., 1890, or of any section or sections of such Act.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay, and inquire into the causes and circumstances of such outbreak; and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and take such measures for the prevention of disease as he is legally authorised to take under any statute in force in the district, or by any resolution of the S.A.

"7. Subject to the instructions of the S.A., he shall direct or superintend the work of the I.N. in the way and to the extent that the S.A. shall approve; and on receiving information from the I.N. that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps as he is legally authorised to take under any statute in force in the district, or by any resolution of the S.A., as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the S.A., he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, and any other article to which the provisions of the P.H.A., 1875, in this behalf shall apply, exposed for sale, or deposited for the purposes of sale, or of preparation for sale, and intended for the food of man; which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be dealt with by a justice, according to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any by-laws and regulations of the S.A., duly confirmed, where confirmation is legally required, in respect of any matter affecting the public health, and touching which they are authorised to frame by-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the S.A., or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report in writing to the S.A. his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall, in like manner, report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the S.A., in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports; and shall produce such book or books, whenever required, to the S.A.

"14. He shall also make an annual report to the S.A. up to the end of December in each year, comprising a summary of the action taken, or which he has advised the S.A. to take, during the year, for preventing the spread of disease, and an account of the sanitary state of his district generally at the end of the year. The report shall also contain an account of the inquiries which he has made as to conditions injurious to health existing in his district, and of the proceedings in which he has taken part or advised under any statute, so far as such proceedings relate to those conditions; and also an account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the S.A. have power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, to dairies, cow-sheds, and milk-shops, and to factories and workshops. The report shall also contain tabular statements [on forms to be supplied by us (the L.G.B.), or to the like effect] of the sickness or mortality within the district, classified according to diseases, ages, and localities.

"Provided that if the M.O.H. shall cease to hold office before December 31 in any year, he shall make the like report for so much of the year as shall have expired when he ceases to hold office.

"15. He shall give immediate information to us (the L.G.B.) of any outbreak of dangerous epidemic disease within the district, and shall transmit to us (the Board) a copy of each annual report, and of any special report. He shall make a special report to us (the L.G.B.) of the grounds of any advice he may give to the S.A., with a view to the closure of any school or schools, in pursuance of the Code of Regulations approved by the Education Department, and for the time being in force.

"16. At the same time that he gives information to us (the L.G.B.) of the outbreak of infectious disease, or transmits to us a copy of his annual or any special report, he must give the like information, or transmit a copy of such report, to the C.C. of the county within which his district may be situated.

"17. In matters not specifically provided for in this Order, he shall observe and execute any instructions issued by us (the L.G.B.), and the lawful orders and directions of the S.A. applicable to his office.

"18. Whenever we (the L.G.B.) shall make regulations for all or any of the purposes specified in sec. 134 of the P.H.A., 1875, and shall declare the regulations so made to be in force within any area comprising the whole or any part of the district, he shall observe such regulations, as far as the same relate to or concern his office."

The duties of the M.O.H. to a P.S.A. are defined by the L.G.B. in terms much the same as those given above, omitting the references to regulated trades and inspection of food, and substituting "ships" for "houses," and "shipping within the district" for "district":—

"He shall inform himself, as far as practicable, respecting all conditions affecting, or threatening to affect, injuriously the health of crews and other persons on shipboard within the district. . . . He shall inquire into, and ascertain by such means as are at his disposal, the causes, origin, and distribution of diseases in the ships and other vessels within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation. . . . He shall, by inspection of the shipping in the district, keep himself informed of the condition injurious to health existing therein. . . . On receiving information of the arrival within the district of any ship having any infectious or epidemic disease of a dangerous character on board, or of the outbreak of any such disease on board any ship within the district, he shall visit the vessel without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, to assist in the execution of the same. . . . On receiving information from the I.N. that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a ship, he shall, as early as practicable, take such steps authorised by the P.H.A., 1875, on that behalf, as the circumstances of the case may justify and require. . . . When any vessel within his district has had dangerous infectious disease on board, he shall give notice thereof to the M.O.H. of any port within the United Kingdom whither such vessel is about to sail."

INSTRUCTIONS OF LOCAL GOVERNMENT BOARD AS TO ANNUAL REPORT.

"Every M.O.H. appointed under the Order of the L.G.B. is required to make an annual report with regard to each sanitary district, or division of a district, which is under his superintendence. This report is to be for the year ending the 31st of December, or, if the officer at that date has not been in office for a whole year, then for so much of the year as has elapsed since his appointment. The report is to be made to the S.A., and a copy of it is to be sent to the L.G.B. by the M.O.H. It should be made as soon as practicable after the expiration of the year to which it relates. The M.O.H. ought not, in general, to have any difficulty in doing this within a month or six weeks; but if, from any special circumstance, the report cannot be completed within six weeks, it should be understood that the delay must not be indefinite, and that the report, complete or incomplete, should be in the hands of the S.A. within, at most, three months from the end of the year. The Board's copy of the report should be forwarded to them when the original is sent to the S.A., except where the report is likely to be printed by order of the authority. In such cases the Board need only be supplied with a printed copy. But in all cases in which the report cannot be sent to the Board within six weeks from the end of the year, they should be informed by the M.O.H. of the reason for the delay. . . . The report should be chiefly concerned with the conditions affecting health in the district, and with the means for improving these conditions. It should consider these subjects with reference to the future as well as to the past, and the account (directed by sec. 14) of the sanitary state of the district generally at the end of the year should, while marking the point that has been reached in the sanitary state and administration of the district, indicate directions for further consideration and action. The sanitary history of the year under review should include a record alike of the proceedings of the M.O.H. himself, and of the proceedings taken under his direction or advice. And the tabular statements of sickness and mortality in the district during the year, to be made on the forms supplied for the purpose, should be the subject of comment in the text of the report, in so far as deductions from them may assist the S.A. to an appreciation of the lines of action needful in the future.

"The M.O.H., in reporting his proceedings and advice, will find it advantageous to follow in the main the order in which the subject-matters of his duty appear in the several paragraphs (of the Order of March 1891), and herein special care should be taken in reporting on the subject of sec. 3. Not only the fact of having made systematic inspections, but the outcome from these inspections, should be duly put on record. They are inspections independent of such inquiries as, under other articles of the Order, the M.O.H. has to make into particular outbreaks of disease, or into unwholesome conditions to which his attention may have been specially called by complaints or otherwise; and the object of these systematic inspections is that he may assure himself that he is well acquainted with all the discoverable circumstances which are likely to affect the public health in his district. How often these inspections require to be made, and how detailed the inquiries should be, must be determined by the particular circumstances of the locality. In some neighbourhoods a house-to-house inspection should, as far as practicable, be made; in others, this may not be needful; but every M.O.H. should at certain times set himself to examine into the state of his district, devoting some time to each portion of it, so as to be sure that no part escapes his notice. Of these inspections, of the judgment he has formed thereon as to the sanitary state of his district, and of the advice he has in consequence given to the S.A., and the action taken by the authority thereon, the annual report should contain a full account. In making such systematic inspection, as in much of his other action, the M.O.H. will usually require the assistance of the I.N.; and it will be for the M.O. to include in his report an account of the action which, at his instance, the inspector may have taken for the removal of nuisances injurious to health.

"As regards the tabular statements of sickness and mortality, only one observation appears to be needful. The district under the superintendence of a M.O.H. will often contain several parts evidently differing in their circumstances, or having very different rates of mortality—either of mortality from all causes, or of mortality from some particular disease or class of diseases. The observation of these differences can scarcely fail to lead to valuable information, and it is in view of such differences that the tabular statements are required in sec. 14 to be classified according to localities, and the provision for such a classification is made in the forms supplied for returns of deaths. In the absence of any ascertained differences of the above sort, it will still be desirable to classify the deaths of the district according to the part of the district in which they occur; and for this purpose any areas of known population (such as parishes, groups of parishes, townships, or wards) may be taken as representing 'localities' for the purposes of the Order. Classification on this basis will be likely to lead to the discovery of real differences when the returns for several years can be compared together.

"What has been said above with regard to the information which an annual report should contain, must be understood, not as suggesting that the report should be limited to these subjects, or that more detailed or differently arranged tabular statements may not be added, but as indicating the minimum of information which will satisfy the requirements of the Board's Order. Many medical officers of health will doubtless, with great advantage to the administration of their district, furnish much more information than this minimum, and this will give prominence to the particular questions to which they have been led by the circumstances of the foregoing year to devote attention, or in the investigation of which they may have arrived at valuable conclusions. Any information of this kind will be appreciated by the L.G.B.

"In addition to the report of the year's illness, mortality, and sanitary work, the M.O.H. should include in his annual report references to the general sanitary state of the district, the legal proceedings instituted by the S.A., and their results, meteorological data, and any other factors influencing the public health."

BASES OF THE ANNUAL REPORT OF THE MEDICAL OFFICER OF HEALTH.

1. The census reports of the Registrar-General as to the population of his district, classified into age- and sex-groups. These should be available for at least the preceding twenty or thirty years, and the M.O.H. should know the estimated population of his district for the year and its age and sex constitution. It is advisable to obtain, at the time of a census, the population of each "enumeration district" included in the area of the S.A. For this the consent of the Registrar-General is required.

2. Weekly returns to the S.A. from the registrar of the district as to all registered deaths. The S.A. may prescribe the form in which such returns shall be made, and must pay for the returns. Deaths of non-residents should be specified in the return, and the M.O.H. should arrange for information of deaths of residents of the locality in public institutions outside the district.

3. Periodic returns to the S.A. from the registrar of the district as to all registered births.

4. Returns of pauper sickness, deaths, and infectious diseases from district

and workhouse medical officers and medical officers of district schools, to the M.O.H. under the L.G.B. Order.

5. Notifications of infectious disease.

6. Maps, both topographical and showing disease distribution in the district. The diseases may be located, according to distribution, by means of different coloured dots.

7. The M.O.H.'s periodical reports to the S.A., which may be weekly, fortnightly, or quarterly (an excellent account of how these may be arranged and kept will be found in Hime's "Practical Guide to the P.H. Acts," 2nd ed., p. 415).

8. Reports of the L.G.B. inspectors, if any, concerning the district.

9. Acts of Parliament, by-laws, and regulations affecting the district.

10. Registers kept by the M.O.H. showing the incidence of infectious and other diseases on special localities and occupations.

[For revised tables issued by the L.G.B., and showing the form in which the M.O.H. must make his returns, see Appendix A, Tables I.–IV.]

Other useful tables of mortality and of infectious diseases, together with a form of interchange of intimation of deaths of non-residents and rules as to classification of causes of death, will be found in Appendix A, Tables V. and VI. et seq. There are the tables, form, and rules drawn up by the committee appointed by the Council of the Incorporated Society of Medical Officers of Health.

DUTIES OF A SANITARY INSPECTOR, AS DEFINED BY THE LOCAL GOVERNMENT BOARD.

"1. He shall perform, either under the special directions of the S.A. or (so far as authorised by the S.A.) under the directions of the M.O.H., or, in cases where no such directions are required, without such directions, all the duties specially imposed upon an I.N. by the P.H.A., 1875, or by any other statute or statutes, or by the orders of the L.G.B., so far as the same apply to his office.

"2. He shall attend all meetings of the S.A. when so required.

"3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement.

"4. On receiving notice of the existence of any nuisance within the district, or of the breach of any by-laws or regulations made by the S.A. for the suppression of nuisances, he shall, as early as practicable, visit the spot and inquire into such alleged nuisances or breach of by-laws or regulations.

"5. He shall report to the S.A. any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any by-laws or regulations made in respect of the same.

"6. He shall report to the S.A. any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

"7. He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the preparation or sale of butcher's meat, poultry, fish, fruit, vegetables, corn, bread, flour, milk, or any other article to which the provisions of the P.H.A., 1875, in this behalf shall apply, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, milk, or other article as aforesaid which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized, and take such other proceedings as may be necessary in order to have the same dealt with by a justice: provided that in any case of doubt arising under this clause, he shall report the matter to the M.O.H. with the view of obtaining his advice thereon.

"8. He shall, when and as directed by the S.A., procure and submit samples of food, drink, or drugs, suspected to be adulterated, to be analysed by the analyst appointed under the S.F.D.A., and upon receiving a certificate stating that the articles of food, drink, or drugs are adulterated, cause a complaint to be made, and take other proceedings prescribed by that Act.

"9. He shall give immediate notice to the M.O.H. of the occurrence within the district of any contagious, infectious, or epidemic disease; and whenever it appears to him that the intervention of such officer is necessary, in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the M.O.H. thereof.

"10. He shall, subject to the directions of the S.A., attend to the instructions of the M.O.H. with respect to any measures which can be lawfully taken by an I.N. under the P.H.A., 1875, or under any statute or statutes, for preventing the spread of contagious, infectious, or epidemic disease of a dangerous character.

"11. He shall enter from day to day in a book provided by the S.A. particulars of his inspections, and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the S.A., so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the P.H.A., 1875, or under any other statute or statutes, and shall keep any other systematic records that the S.A. may require.

"12. He shall, at all reasonable times, when applied to by the M.O.H., produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of an I.N. relate.

"13. He shall, if directed by the S.A. to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"14. He shall, if directed by the S.A. to do so, act as officer of the said authority as L.A., under the Diseases (Animals) Acts, and any Orders or Regulations made thereunder.

"15. In matters not specially provided for in this Order, he shall observe and execute all the lawful orders and directions of the S.A. and the orders of the L.G.B. which may be hereafter issued, applicable to his office."

SANITARY LAW.

DEFINITIONS.

Certain terms are specially defined in the various Sanitary Acts. Some of these definitions will be found under the Acts themselves, the more important of the others being here given.

Ashpit includes any ashtub or other receptacle for the deposit of fæcal matter or refuse (P.H.A.A.A., 1890).

Building.—This is a term which frequently recurs, and includes a great variety of erections, whether with or without foundations, or elevated on wheels. With regard to infectious disease, it embraces also vessels, boats, sheds, tents, etc., used for human habitation.

Canal includes any river, inland navigation, lake, or water, being within the body of a county, whether it is or is not within the ebb and flow of the tide (C.B.A., 1877).

Canal boat means any vessel, however propelled, which is used for the conveyance of goods along a canal, as above defined, and which is not a ship registered under the Merchant Shipping Act, 1854, and the Acts amending the same (C.B.A., 1877). The L.G.B., however, is empowered to declare any such excepted boat to be a canal boat (C.B.A., 1884).

Common lodging-house means a lodging-house, or part thereof, in which persons of the poorer classes are received for short periods, and, though strangers to one another (*i.e.* though lodgers promiscuously brought together), are allowed to inhabit one common room.

Contributory place.—This may be either—(1) a special drainage area ; (2) a parish wholly outwith a special drainage district ; (3) that part of a rural parish which is excluded from a special drainage district ; (4) that portion of an urban parish which is not in the urban district or in a special drainage district.

Curtilage is defined as "a courtyard, backside, or piece of ground lying near to a dwelling-house."

Dairy shall include "any farm, farmhouse, cow-shed, milk-store, milk-shop, or other place from which milk is supplied, or in which milk is kept for purposes of sale" (I.D.P.A., 1890). Dairy also means a dairy in which cattle are not kept (Model Regulations of L.G.B. for Dairies, Cow-sheds, and Milk-shops).

Drain means "any drain of, and used for the drainage of, one building only or premises within the same curtilage, and made merely for communicating therefrom with a cesspool or like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed" (P.H.A., 1875).

Dwelling-house means "any inhabited building, and includes any yard, garden, outhouses, and appurtenances belonging thereto, or usually enjoyed therewith, and includes the site of the dwelling-house so defined" (H.W.C.A., 1890, Part II.).

Earth-closet is defined as any place for the reception and deodorisation of fæcal matter, constructed to the satisfaction of the local authority (P.H.A., 1875).

Horse-flesh is such flesh, cooked or uncooked, alone or mixed with other substances, and includes the flesh of asses and mules (Sale of Horse-flesh, etc., Regulation Act, 1889).

House includes schools, factories, and other buildings in which more than twenty persons are employed at one time (P.H.A., 1875).

Houses let in lodgings.—A "lodging-house" is defined as a house or part of a house let in lodgings, or occupied by members of more than one family. *Model By-laws* (L.G.B.).

Lands and premises include messuages, buildings, lands, casements, and hereditaments of any tenure (P.H.A., 1875).

Nuisance.—(*a*) *Common.*—"Anything which worketh hurt, inconvenience, or damage to any one" (Blackstone).

(*b*) *Statutory.*—"Something which either actually injures, or is likely to injure health, and admits of a remedy, either by the individual whose act or omission causes the nuisance, or by the local authority" (Wynter-Blyth).

Owner means the person for the time being receiving the rack-rent (see infra) of the lands and premises in connection with which the word is used, whether on his own account or as agent or trustee for any other person, or who would so receive the same if such lands or premises were let at a rack-rent (P.H.A., 1875).

Premises.—See *Lands.*

Rack-rent means rent that is not less than two-thirds of the full net annual value of the property out of which the rent arises (P.H.A., 1875).

Sewer includes sewers and drains of every description, except drains to which the word "drain" interpreted as aforesaid applies, and except drains vested in or under the control of any authority having the management of roads and not being a local authority under this Act (P.H.A., 1875).

Slaughter-house includes the buildings and places commonly called slaughter-houses and knackers' yards, and any building or place used for slaughtering cattle, horses, or animals of any description (P.H.A., 1875).

Street includes any highway (not being a turnpike road), and any public bridge (not being a county bridge), and any road, lane, footway, square, court, alley, or passage, whether a thoroughfare or not (P.H.A., 1875).

Waterworks includes streams, springs, wells, pumps, reservoirs, cisterns, tanks, aqueducts, cuts, sluices, mains, pipes, culverts, engines, and all machinery, lands, buildings, and things for supplying or used for supplying water, also the stock-in-trade of any water company.

BY-LAWS.

A by-law, as defined by Lumley, is "a law made with due legal obligation by some authority less than the Sovereign and Parliament, in respect of a matter specially or impliedly referred to that authority and not provided for by the general law of the land." By-laws are intended to supplement the provisions of Parliamentary statutes, and must fulfil the following conditions:—

"1. A by-law must be consistent with, and not repugnant to, the general law.

"2. It must provide something in addition to the general law, and therefore must not simply re-enact it.

"3. It must not make a provision in respect of a matter already provided for other than what the general law has prescribed.

"4. It must be certain in its enactment, that is, free from ambiguity, and must afford complete direction to those who are to obey it.

"5. It must be general in its application.

"6. It must be reasonable.

"7. It must be positive in its terms, and directed to prohibit or enjoin an act by the person upon whom it is to operate.

"8. It must prescribe a definite penalty for its contravention.

"9. It must not be ultra vires, that is, it must refer to a matter within the authority of the body enacting it, and must operate upon persons or in a district subject to their control.

A L.A. may make either by-laws or regulations on various subjects, but while the former require confirmation by a superior authority, such is not the case with the latter. A by-law has no force or effect until it has been confirmed, but after confirmation has all the force of an Act of Parliament. A by-law may be altered or rescinded by a subsequent by-law, which likewise requires confirmation prior to its having legal effect. In respect of sanitary matters the confirming authority is the L.G.B.

POWER TO MAKE BY-LAWS.

In England and Wales an U.A. may make by-laws under the P.H.A., 1875, and various other statutes, on the following subjects:—

(1) (*a*) The cleansing of footways and pavements, the removal of house refuse, the cleansing of earth-closets, privies, ashpits, and cesspools. (*b*) The prevention of nuisances arising from snow, filth, dust, ashes, and rubbish, and the prevention of the keeping of animals so as to be injurious to health (s. 44, P.H.A., 1875).

(2) The regulation and management of common lodging-houses (s. 80, P.H.A., 1875).

(3) The regulation and management of houses let in lodgings (s. 90, P.H.A., 1875).

(4) Offensive trades, the prevention of injurious effects from (s. 113, P.H.A., 1875).

(5) The management of public mortuaries (s. 141, P.H.A., 1875).

(6) The construction and arrangement of new streets and buildings, and the closure of buildings unfit for human habitation (s. 157, P.H.A., 1875).

(7) The regulation of public walks and pleasure grounds (s. 164, P.H.A., 1875).

(8) The regulation of markets (s. 167, P.H.A., 1875).

(9) The management and regulation of slaughter-houses provided by U.A. (s. 169, P.H.A., 1875).

(10) The licensing for hire, *e.g.* of cabs, boats, etc. (ss. 171 and 172, P.H.A., 1875).

(11) The lodging and accommodation of hop-pickers (s. 314, P.H.A., 1875).

Under the other statutes the U.A. may make by-laws for—

(12) The decent conduct of persons using public sanitary conveniences (s. 20, P.H.A.A.A., 1890).

(13) The construction and arrangement of new buildings, the removal of refuse therefrom, and the provision of adequate flush for water-closets therein (s. 23, P.H.A.A.A., 1890).

(14) (*a*) The prescription of time for removing filth, the proper construction of filth receptacles, and the cleansing of places fouled during the

removal of filth. (*b*) Also the imposition of duties on occupiers in connection with such removal by the L.A. (s. 26, P.H.A.A.A., 1890).

(15) The prevention of danger from certain public amusements (s. 38, P.H.A.A.A., 1890).

(16) The regulation of pleasure boats on water within public pleasure grounds (s. 44, P.H.A.A.A., 1890).

(17) The management of lodging-houses provided under the H.W.C.A., 1890.

(18) The regulation and management of moveable dwellings (H.W.C.A., 1885).

(19) The licensing, registration, etc. of knackers' yards and slaughter-houses (Towns Improvement Clauses Act, 1847).

(20) The provision of decent lodging and accommodation for fruit-pickers (Public Health (Fruit-Pickers' Lodgings) Act, 1882).

R.As. can make by-laws with regard to Nos. (1*a*), (2), (3), (5), (10), (11), (13), (14 *b*), (17), (18).

The power to make by-laws is permissive, but every S.A. must make by-laws as to common lodging-houses, and every U.S.A. as to slaughter-houses, which they provide. The L.G.B. may allow or disallow a by-law; and all by-laws, which must be under the common seal of the S.A., when confirmed, must be printed and hung up in the office of the S.A., and a copy of them must be delivered to any ratepayer of the district who may apply for them.

In London, the L.C.C. have power to make by-laws under such Acts as the P.H.(L.) Act, 1891, the London Building Act, 1894, etc. They must make by-laws with regard to certain matters, *i.e.* removal of filth, the sanitary conveniences of buildings, etc. The Metropolitan S.A. and the Commissioners of Sewers may also make by-laws, and in some instances must make them with regard to various sanitary matters.

In Ireland, by-laws may be made under the P.H. (Ireland) Acts, which closely resemble the English P.H.A., 1875.

In Scotland, under the P.H.(S)A., 1897, a L.A. has power to make by-laws regarding—

(1) Offensive trades (s. 32). This includes slaughter-houses and removal of refuse.

(2) Pigstyes (s. 35).

(3) Public conveyances (s. 65).

(4) Public mortuaries (s. 68).

(7) Houses let in lodgings (s. 72).

(8) Tents and vans (s. 73).

(9) Common lodging-houses (s. 92).

(10) Removal of infected persons from ships to hospital (s. 180).

(11) Buildings (s. 181) subject to approval of C.C.

Under the B.P.(S.)A. 1892, a L.A. has power to make by-laws regarding—

(12) Prevention of nuisances.

(13) Knackers' yards.

(14) (*a*) Removal of filth; (*b*) prevention of soakage from foul waters; (*c*) prevention of nuisance from filth.

(15) Inspection and cleansing of cisterns in certain dwellings.

(16) Regulation of time and mode of removal of offensive matter.

(17) Storage of offensive matter.

(18) Offensive trades.
(19) Keeping of animals.
(20) Cleansing of courts, stairs, common water-closets, etc.
(21) Drainage of houses; soil pipes and water-closets.

MODEL BY-LAWS.

The L.G.B. have issued "Model By-laws" for the guidance of S.As. empowered to make by-laws on sanitary matters. The plan of these model by-laws has been usually followed by S.As. in framing their own by-laws, though occasionally modifications are introduced and submitted to the L.G.B. for sanction. The subjects on which model by-laws have been issued by the L.G.B. are—

1. Cleansing and scavenging.
2. Nuisances.
3. Common lodging-houses.
4. New streets and buildings.
5. Markets.
6. Slaughter-houses.
7. Hackney carriages.
8. Public bathing.
9. Baths and wash-houses.
10. Pleasure grounds.
11. Horses, etc., standing for hire.
12. Pleasure boats and vessels.
13. Houses let in lodgings.
14. Cemeteries.
15. Mortuaries.
16. Offensive trades.
17. Temporary dwellings.
18. Tents, vans, etc.

REGULATIONS.

As already stated, a sanitary regulation made by a S.A. differs from a by-law in not requiring confirmation by the L.G.B. Certain regulations, however, require the approval of a superior authority, which in the case of the removal of infected persons from any vessel and their detention in hospital, is no other than the L.G.B. In such a case breach of the regulation renders the offenders liable to a money penalty. Regulations may be made by resolution of the L.A., and may be amended or rescinded by subsequent resolutions. Their publication is advisable, though not compulsory as in the case of by-laws. The L.G.B. may make regulations, and have done so respecting such subjects as canal boats, burial grounds, cholera, yellow fever, and plague; epidemic diseases; dairies, cow-sheds, and milk-shops.

SANITARY ACTS.

Sanitary law is a comprehensive term, embracing a large number of different statutes dealing with various subjects in their relation to the health of the people.

These subjects dealt with by legislative enactment are best considered seriatim, the various laws applying to each being considered under the respective headings. There are four main Public Health Acts, for England and Wales, London, Ireland, and Scotland respectively, these are the P.H.A., 1875; P.H.A. (London), 1891; P.H.A. (Ireland), 1878; and the P.H.A. (Scotland), 1897. The first three will be considered together, the more recent Scottish Act is best discussed by itself. In addition to these P.H.As., many minor acts apply with equal force to all parts of the country; these will be considered in detail in their application to England and Wales, and merely referred to thereafter.

ENGLAND AND WALES, LONDON, AND IRELAND.

Collection and Removal of Excreta and Refuse—General Cleansing.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875; P.H.A.A.A., 1890, Part III. (adoptive); L.G.A., 1894; C.M.R.A., 1887. In addition, Model By-laws.

P.H.A., 1875.

Ss. 35–38.—It is unlawful to newly erect or rebuild any house without a sufficient water-closet, earth-closet, or privy, and an ashpit provided with proper doors and coverings; and the L.A. may require similar provision to be made in any existing house, and may decide as to the sufficiency of the accommodation where the inmates of more than one house have the common use of such sanitary conveniences. Where earth-closets are in use with the approval of the L.A., the L.A. may supply dry earth or other deodorant, and may dispense with the supply of water which a water-closet would require.

The L.A. may compel the provision in any factory, in which both sexes are employed or intended to be employed at one time, of separate sanitary conveniences for each sex.

S. 39.—Any U.A. may, if they think fit, provide and maintain sanitary conveniences for public accommodation.

S. 40.—Every L.A. shall provide that all closets, privies, ashpits, and cesspools in their district be constructed and kept so as not to be a nuisance or injurious to health.

S. 41 enacts that if written complaint be made to the L.A. by any person that any water-closet, earth-closet, privy, ashpit, or cesspool is a nuisance or injurious to health, the L.A. have powers of entry and of opening the ground and of examination. If any defect be found, the L.A. may compel the owner or occupier to do the necessary works, or, in his default, may do the work themselves, and recover the expense from the owner in a summary manner. If no defect be found, the L.A. must close the ground and make good any damage at their own expense.

S. 42.—Every L.A. may, and when required by the L.G.B. shall, themselves undertake or contract for—(1) the removal of house refuse from premises; (2) the cleansing of earth-closets, privies, ashpits, and cesspools. In addition, the proper cleansing and watering of streets may be undertaken by any U.A. and by any R.A. authorised by the L.G.B.

S. 43 provides a small penalty if the L.A., after notice, neglect the first two of these matters in s. 42.

S. 44.—The L.A. may by by-law impose on occupiers the duty of such cleansing and removal as mentioned in s. 42, and also of the cleansing of footways adjoining their premises.

An U.A. may also make by-laws for the prevention of nuisances arising from snow, filth, dust, ashes, and rubbish, and for the prevention of the keeping of animals on any premises so as to be injurious to health.

S. 45.—An U.S.A. may provide receptacles for dust, ashes, and rubbish.

S. 46.—On the certificate of the M.O.H., or two medical practitioners, that any house or part thereof is so filthy as to endanger health, or that the whitewashing, cleansing, or purifying thereof would tend to check or prevent infectious disease, the L.A. may require the owner or occupier to purify it, and, in his default, may themselves do what is necessary and recover the cost.

S. 47.—"Any person who in any urban district—(1) keeps any swine or pigstye in any dwelling-house or so as to be a nuisance to any person, or (2) suffers any waste or stagnant water to remain in any cellar or place within any dwelling-house for twenty-four hours after written notice to him from the U.A. to remove the same, or (3) allows the contents of any water-closet, privy, or cesspool to overflow or soak therefrom, shall, for every such offence, be liable to a penalty not exceeding 40s., and to a further penalty not exceeding 5s. for every day during which the offence is continued, and the U.A. shall abate or cause to be abated every such nuisance, and may recover in a summary manner the expenses incurred by them in so doing from the occupier of the premises on which the nuisance exists."

S. 48 relates to the cleansing of offensive boundary ditches.

S. 49.—The I.N. of an U.S.A. may give notice to remove within twenty-four hours any offensive accumulation. Such notice is given to the person to whom the same belongs, or to the occupier of the premises whereon it exists. In case of non-compliance, the U.A. may remove and sell it, and take their expenses from the proceeds of sale.

S. 50.—An U.S.A. may give public notice requiring the periodic removal of manure or other refuse matter from mews and other premises, under penalty.

S. 157.—Every U.A. may make by-laws "with respect to the drainage of buildings, to water-closets, earth-closets, privies, ashpits, and cesspools in connection with buildings, and to the closing of buildings or parts of buildings unfit for human habitation." There are certain restrictions in the section as to the buildings to which such by-laws may apply, and these restrictions are modified if the next Act is adopted.

P.H.A.A.A., 1890 (Adoptive).

Part III. of this Act refers to sanitary matters, and may be adopted by U.S.As. Certain sections may be adopted also by R.S.As.

S. 20.—If an U.A. have acted under s. 39, P.H.A., the U.A. may make regulations regarding such conveniences, and may charge for the use of water-closets. Further, no public sanitary convenience, other than in connection with a railway station, can be erected in a street without the consent of the U.A.

S. 21.—In the case of sanitary conveniences used in common by the inmates of two or more dwellings or by other persons, penalties are provided for injury to, or improper fouling of, such conveniences, and for allowing such conveniences to become a nuisance for want of proper cleansing.

S. 22.—This is a clause in substitution of s. 38 of the P.H.A. It requires that in every workshop or factory sufficient sanitary conveniences shall be provided for the employed and attendants, and separate accommodation for each sex.

S. 23.—This extends s. 157 of the P.H.A., and empowers every U.A.

to make by-laws as to—(1) keeping water-closets supplied with sufficient water for flushing; and (2) provision in laying out new streets of secondary means of access for the purpose of removal of house refuse. It further extends the application of the by-laws of the U.A. to all buildings, and provides R.As. who have adopted this Act, with the same powers as U.As. in relation to these matters. Every L.A. may make accessory by-laws to prevent such alteration of buildings as would contravene the by-laws.

S. 26.—"(1) An U.A. may make by-laws in respect of the following matters, namely:—(*a*) For prescribing the times for the removal or carriage through the streets of any fæcal or offensive or noxious matter or liquid, whether such matter or liquid shall be in course of removal or carriage from within, or without, or through their district.

(*b*) "For providing that the vessel, receptacle, cart, or carriage used therefor shall be properly constructed and covered so as to prevent the escape of any such matter or liquid.

(*c*) "For compelling the cleansing of any place whereon such matter or liquid shall have been dropped or spilt in such removal or carriage.

(2) "Where a L.A. themselves undertake or contract for the removal of house refuse, they may make by-laws imposing on the occupier of any premises duties in connection with such removal, so as to facilitate the work which the L.A. undertake or contract for."

Note that the first portion of this section applies only to U.S.As., the second to both U.S.As. and R.S.As.

S. 27.—"(1) Where any court or where any passage leading to the back of several buildings in separate occupations, and not being a highway reparable by the inhabitants at large, is not regularly and effectually swept and kept clean and free from rubbish or other accumulation to the satisfaction of the U.A., the U.A. may, if they think fit, cause to be swept and cleaned such court or passage.

"(2) The expenses thereby incurred shall be apportioned between the occupiers of the buildings situated in the court or to the back of which the passage leads, in such shares as may be determined by the surveyor of the U.A., or, in case of dispute, by a court of summary jurisdiction, and in default of payment, any share so apportioned may be recovered summarily from the occupier on whom it is apportioned."

The U.A. may cause to be swept and cleaned any dirty court or passage, and charge the cost to the neighbouring occupiers.

L.G.A., 1894.

S. 8 (1, *f*).—The P.C. may deal with any place containing matter prejudicial to health by cleansing, or other method of preventing it from being prejudicial to health.

C.M.R.A., 1887.

S. 74.—In those portions of a mine above ground sufficient separate sanitary conveniences must be supplied for both sexes, if women and girls be employed.

MODEL BY-LAWS.

The L.G.B. have issued a series of model by-laws which they recommend for the guidance of L.As., and which come into force if promulgated by the

L.A. and confirmed by the L.G.B. Those relating to the subjects under consideration are here given—

Water-closets, Earth-closets, Privies, Ashpits, and Cesspools.

At least one side of every water-closet and earth-closet in a building shall be an external wall. Every water-closet and earth-closet in connection with a building shall have a window opening direct into the external air, not less than 2 ft. × 1 ft., exclusive of the frame. There shall further be provided means of constant ventilation by at least one air-brick in an external wall, or air-shaft, etc. Every water-closet in connection with a building shall have a separate and adequate cistern, service-box, or flushing-box.

There must be suitable water supply and means of flushing and of removing filth. The receptacle must be suitable, made of non-absorbent material, must hold a sufficient quantity of water, and catch filth without soiling of the sides. Containers and D-traps are prohibited. An earth-closet may have either a fixed or a movable receptacle; if the former, it must not be larger than will suffice for three months, must be at least 3 in. above the ground in every part, and must not in any case exceed 40 cubic ft. in capacity; if the latter, its capacity may be about 2 cubic ft. The receptacle must not leak or absorb the contents, and must be accessible for cleansing or removal, but must not be accessible to rainfall or drainage. A proper supply of dry earth or other deodorant must be at hand, and there must be suitable means for applying it to the filth. The situation, lighting, and ventilation of an earth-closet should be similar to those of a water-closet.

A privy must be at least 6 ft. distant from a dwelling-house, public building, factory, or workshop, and at least 50 ft. from any water likely to be used for drinking or domestic purposes. The position and construction of a privy must be such as to admit of removal of its contents without conveying them through any house, trade premises, or other building. The floor of the privy must be impervious, must be 6 in. above the level of the adjoining ground, and must slope towards the door, with a fall of at least half an inch in a foot. A privy must not be entirely closed, but must have a ventilating opening near the top, and must be protected from the access of rainfall and waste water. No connection with a drain is allowed. The receptacle may be fixed or movable, and must be 3 in. above the surface of the adjoining ground. If fixed, there must be means of supplying ashes, etc., to the filth, and the receptacle must be of non-absorbent material, must not leak, must not exceed 8 cubic ft. in capacity, and must be readily accessible for cleansing. If movable, the whole area beneath the seat must be asphalted or flagged, and have solid impermeable sides 8 in. thick, built of flag, slate, or brick, properly cemented or asphalted. The receptacle must be non-absorbent, free from leaks, and must not exceed 2 cubic ft. in capacity.

Ashpits must conform to the same requirements as a privy with movable receptacle, with regard to—(1) contiguity to buildings and to water used for consumption; (2) removal of contents; (3) level; (4) construction; (5) ventilation; (6) disconnection from any drain; (7) accessibility for cleansing. An ashpit must be provided with a door which can be fastened when closed, and must not exceed in capacity 6 cubic ft., or such other size as may suffice to hold one week's accumulations.

Cesspools must be constructed of good brickwork in cement, properly rendered inside with cement, and with a backing of at least 9 in. of well-puddled clay around and beneath the brickwork. They must be ventilated, but must not be connected with any sewer. The interior must be accessible for cleansing, and the contents must be removable without the necessity of carrying them through any dwelling, public building, or trade premises. Cesspools must not be within 50 ft. of such buildings, nor within 100 ft. of water used for consumption, nor in any position in which they are likely to pollute water supplies.

Cleansing of Earth-closets, Privies, Ashpits, and Cesspools.

The occupier of any premises must cleanse—

Earth-closets with fixed receptacles . .	once in three months.
,, ,, movable ,, . .	,, a week.
Privies, with either fixed or movable receptacles,	once a week.
Ashpits, whether used for excreta or not,	,, ,,
Cesspools	once in three months.

Cleansing of Footways and Pavements.

The occupier of any premises fronting, adjoining, or abutting on any street shall, once at least in every day, Sundays excepted, cleanse the footways and pavements adjoining such premises.

Removal of House Refuse.

The occupier of any premises shall, once at least in every week, remove the house refuse from such premises.

Prevention of Nuisance from Snow, Filth, Dust, Ashes, and Rubbish.

The occupier, of any premises must remove snow from the footways and pavements, adjoining his premises, as soon as possible after it ceases to fall, and must so deposit it as not to cause undue accumulation in any channel or carriage-way, or upon any paved crossing. Any mixture of snow and salt must be forthwith removed.

An occupier, in removing any filth, dust, ashes, or rubbish from his premises, must not allow any deposit thereof on any footway, pavement, or carriage-way, and any inadvertent deposit in such places must be followed by thorough sweeping and cleansing. The refuse may only be removed in a properly constructed and covered vehicle, and if from premises within 20 yds. of any dwelling, place of business, or public building, in the early hours of the morning, namely, 6 to 8 a.m., or during the four winter months, 7 to 9 a.m.

No collection of filth must be deposited for more than (twenty-four) hours within (100) yards of any street, dwelling, public building, or place of business. Night soil deposited for agricultural purposes upon land or premises within (100) yards of any street, house, school, etc., must be dug or ploughed into the ground, or be covered with earth or other material sufficient to prevent offensive effluvia, unless the deposit has been previously deodorised.

Prevention of Nuisance from the Keeping of Animals.

Swine must not be kept within (100) ft. of any dwelling, nor must swine or cattle be kept so as to pollute any water used, or likely to be used, for drinking, domestic, or dairy purposes, or for manufacturing drinks. The same prohibitions apply to the storage of dung.

The occupiers of places where cattle, horses, or swine are kept shall provide drains and a suitable receptacle for dung, manure, or other offensive matter. The receptacle must be water-tight, covered, its lowest part must be above the surface of the adjoining ground, and it must be cleansed once a week.

The drain must be properly constructed, kept in good order, and connected with a sewer or cesspool.

LONDON.

Acts Concerned.

P.H.(L.)A., 1891. In addition, Model By-laws.

By this Act the L.C.C. can make by-laws (which do not extend to the City) concerning water-closets, earth-closets, privies, ashpits, and cesspools, refuse removal, and dung receptacles; and also prescribing the times—(1) for the removal of any offensive matter in any way through London, and for the proper construction of vessels or carriages used for such a purpose; (2) for the closing up of privies and cesspools, and the removal of refuse.

Every new house must have one or more water-closets and proper accessories thereunto; and no earth-closet or privy may be substituted unless the available sewerage or water supply is insufficient for a water-closet.

Every person who intends to fix a new sanitary convenience must give notice to the Borough Council. Otherwise, the provisions are very similar to those in force in the provinces. The S.A. in London must cleanse the streets, footpaths, earth-closets, privies, ashpits, and cesspools, and remove house refuse, and also trade refuse, if its removal be paid for. The collection of house and street refuse is an offensive trade. Every S.A. is required to make by-laws—(1) For the prevention of nuisance arising from the keeping of animals on any premises. Swine must not be kept within 40 yds. of any street or public place, nor be allowed to stray in any public place. (2) For the prevention of nuisance from snow, ashes, filth, etc., in any street. (3) For the prevention of nuisance from offensive matter running out of trade premises. (4) For prevention of nuisance from the unpaved condition of yards and open spaces in connection with dwelling-houses.

The following deeds are penalised in the Act:—(1) Discontinuing the water supply to a water-closet without lawful authority. (2) Constructing or repairing a closet so as to cause it to be a nuisance, or injurious or dangerous to health, or wilfully injuring it with the same result. (3) Contravention of by-laws as to construction or reconstruction of a water-closet.

IRELAND.

Acts Concerned.

P.H.(I.)A. 1878. In addition, Model By-laws.

The law in Ireland is very similar to that in England as regards sanitary conveniences, and the ventilation of cesspools may be enforced.

As regards cleansing and scavenging, the Irish authorities, both urban and rural, are compelled to provide receptacles for the deposit of rubbish, and the L.G.B. may require an U.S.A. to make by-laws for the prevention of nuisances following on street accumulations. The requirements of the Irish Act are almost the same as those of the English Act.

Sewerage and Drainage.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875; P.H.A.A.A., 1890, Part III. (adoptive); P.H.A.A.A., 1883 (Support of Sewers); L.G.A., 1894; R.P.P.A., 1876, 1893. In addition, Model By-laws.

P.H.A., 1875.

S. 13.—All existing and future sewers and buildings and works connected therewith are vested in and controlled by the L.A., except—(1) Sewers made by any person for profit. (2) Sewers made and used for the drainage or improvement of land under a local or private Act of Parliament, or for the irrigation of land. (3) Sewers under any Commissioners of Sewers appointed by the Crown.

S. 14.—The L.A. may purchase or otherwise acquire a sewer, or the right of making or using a sewer, but must not deprive a previous user of the right to use a sewer, or a substitute thereof.

S. 15.—The L.A. must keep in repair all sewers, and provide the necessary sewers for effectually draining their district.

S. 16 provides the L.A. with powers as to the laying of sewers, and of taking them through, across, or under land, streets, and cellars or vaults, apart from those under buildings.

S. 18. The L.A. may alter, discontinue, close, or destroy any sewer belonging to them, provided no nuisance is occasioned thereby, and no one deprived of sewerage be left without an effectual substitute sewer.

S. 19.—Sewers must be so constructed, covered, ventilated, and kept as not to be a nuisance or injurious to health, and must be properly cleansed and emptied.

S. 21.—The owner or any occupier of any premises within the district may unite his drains with the sewers of the L.A. on due notice, and on execution of the work in accordance with the regulations, and under the superintendence of the L.A. Contravention of these conditions is visited by a penalty of not more than £20, and the cost of restoration of the integrity of the sewer.

S. 23.—Where any house is without a sufficient drain, the L.A. must require the owner or occupier to make a covered drain, and may prescribe the materials, size, level, and fall of such drain, which must lead to the public sewer if there be any within 100 ft. of the site of the house, and if not, to a covered cesspool in such position as the L.A. may direct, but not in any case under any house. In default, the L.A. may themselves carry out the works, and recover the cost from the owner.

S. 24.—The L.A. may require a house to be drained into a new sewer if the old drain be not adapted to the general sewerage system of the district, or is otherwise objectionable. The L.A. may close the old drain on condition of supplying another, and are responsible for the cost.

S. 25.—In any urban district it is unlawful to erect, build, or occupy any new building unless and until it is properly drained, as specified in s. 23.

S. 26 provides a penalty for the erection of any building over a sewer of an U.S.A., without the written consent of the U.S.A.

Ss. 32–34 prescribe the conditions under which a L.A. may execute sewerage works outside its own district; these comprise due public notice, and, in the event of objection, the sanction of the L.G.B. Local inquiry and report by an inspector of the L.G.B. may be applied for by the L.A.

S. 40.—All drains must be so constructed and kept as not to be a nuisance or injurious to health, and it is the duty of the L.A. to ensure this.

S. 41 and s. 157, already cited (pp. 490, 491), apply to drains as to sanitary conveniences.

By-laws with regard to the construction of drains, etc., apply to new drains, and there is no power to compel the alteration of existing drains, so as to make them conform to the by-laws, unless they are so bad as to require complete rebuilding.

S. 299.—If a L.A. fail to provide and maintain sufficient sewers for the district, and if complaint be made to the L.G.B., the L.G.B. may compel the L.A. to do their duty.

S. 308.—The L.A. is bound to compensate for any damage done in carrying out the provisions of this Act.

P.H.A.A.A., 1890 (Adoptive).

Ss. 16, 17.—No person may throw or pass into any sewer or drain any matter or substance which may interfere with the flow of its contents, or injure the sewer or drain. No person may discharge into any sewer or drain any chemical refuse, waste steam, or liquid at a higher temperature than 110° F. which, either alone or in combination with the sewage, causes a nuisance or is injurious or dangerous to health. The L.A. have powers of entry to ascertain contraventions of this section.

S. 18 is a provision as to the L.A. making communications with, or altering, drains and sewers.

S. 19.—For the purposes of s. 41, P.H.A., 1875, this section gives a definition that the drain of more than one building, where the buildings belong to different owners, is a drain for which such owners are responsible, and the L.A. can make such drain secure and sound if it be defective or a nuisance, and can recover the cost from the owners. If the different buildings, however, belong to one owner, such drain is a sewer for which the L.A. itself is responsible.

S. 23 extends the operation of s. 157, P.H.A., 1875, to all buildings, and gives to R.S.As. the powers conferred by that section.

P.H.A.A.A., 1883.

Support of Sewers.

This is concerned with the safety of sanitary works, such as sewers, which may be affected by mining operations.

L.G.A., 1894.

S. 8 (1, *f*).—The P.C. may deal with any pond, pool, open ditch, drain, or place containing or used for the collection of any drainage, filth, stagnant water, or matter likely to be prejudicial to health, by draining, cleansing, covering it, or otherwise preventing it from being prejudicial to health; but the P.C. must not interfere with any private right, or the sewage or drainage works of any L.A.

S. 16 gives powers to C.C. with regard to sewerage when a P.C. complains of a defaulting R.S.A. It also lays down that where a R.S.A. has determined to adopt plans for the sewerage of any contributory place, the R.S.A. must give notice to the P.C. of any parish for which the works are to be provided, before entering into any contract for the execution of the works.

R.P.P.A., 1876.

S. 7.—Every L.A. is to afford facilities for factories draining into sewers, provided that nothing injurious is admitted, but the L.A. is not bound to provide new sewers for such factories if the former sewers are not of sufficient size (see p. 563, R.P.P.A.).

As to what is injurious, note s. 17, P.H.A.A.A., 1890 (p. 497).

MODEL BY-LAWS.

Drainage of Buildings.

Damp sites must be drained by earthenware field pipes, and such drains must not communicate directly with a sewer or cesspool, but must be properly laid to a suitable outfall.

Rain pipes must be provided to carry away all water falling on the roof, and prevent dampness of walls or foundations. The level of the lowest storey must be such as to allow of the drain from the building having sufficient fall, and yet entering the sewer at a point above the centre of the sewer. All house drains for sewage must be made of glazed stoneware or other impervious material, and must be not less than 4 in. in internal diameter; they must be laid with a proper fall in a bed of concrete, and be jointed so as to prevent leakage. Every drain inlet not intended for ventilation must be trapped. No drain conveying sewage must pass under a building unless no other mode of construction is practicable; in that case it must be laid in a direct line for the whole distance beneath the house, and must be embedded in and covered with concrete 6 in. thick all round, and must be laid at a depth below the surface at least equal to its diameter, and, lastly, must be ventilated and trapped at each end of the portion beneath the building. The main house drain must be trapped at a distance from the house, and before entering the sewer. The junctions of drains must not be at right angles, and tributary drains must join other drains obliquely in the direction of flow.

As to the ventilation of drains, there must be at least two untrapped ventilating openings into the drains, and these may be arranged thus—(1) One opening at or near the ground-level, connected with the drains by a pipe, shaft, or disconnecting chamber, as near as possible to the trap on the main house drain, and on the house side of that trap. The other opening is at the top of a vertical pipe or shaft, never less than 10 ft. high, and usually much more. This shaft must be so placed that foul air escaping from it shall not enter any building, and it is connected with the drain at a point as far distant from the aforesaid trap as possible. (2) If the above arrangement is impracticable, the openings may be reversed, the ground-level opening being at the head of the drain, and the tall shaft near the trap. Further requirements are that the ground-level opening must have a perforated cover or grating, with apertures equal in total area to the sectional area of the drain. The pipes and shafts used must have a sectional area equal to that of the drain, and must never be less than 4 in. in diameter, and should have no bend or angle. The soil pipe of a water-closet may be used as a ventilating shaft if it fulfil all these conditions.

As to arrangement of drains in a house, no drain inlet shall be made within a house except the inlet necessary for a water-closet. The soil pipe of every water-closet must be at least 4 in. in diameter throughout its whole length, must be placed outside the house, and must be carried up full-bore, if possible without bends or angles, to such a height and such a point as to afford a safe outlet for sewer air. There must be no trap between the soil pipe and the drain with which it is connected, and no trap at any point of the soil pipe, except the trap essential in the construction of a water-closet. The waste pipe of a slop sink must conform to the same requirements as a soil pipe. The waste pipe from any other sink, bath, or lavatory, the overflow from every cistern, and from every safe under any bath or water-closet, and every pipe for conveying waste water, must pass through an external wall, and discharge in the open air over a channel leading to a trapped gully, at least 18 in. distant.

LONDON.

Acts Concerned.

Metropolis Management Acts, 1855, 1862; Metropolitan Main Drainage Act, 1858; Metropolitan Management Amendment Act, 1879; City of London Sewers Act, 1848; P.H.(L.)A. 1891. In addition, Model By-laws.

In London the main sewers and drains are vested in the L.C.C., while the Borough Councils are responsible for other drains and sewers.

In the City of London the Commissioners of Sewers are the L.A.

No new sewers can be made without the approval of the L.C.C.

In London the term "sewer" includes many combined drains, for which in the provinces the owners of premises would be responsible, but which in London are vested in the L.A. In other respects the provisions of the London Acts closely resemble those in force in England and Wales, and the L.C.C. can make by-laws regarding house drainage. Wilful destruction, damage, stopping up or interference with any drain, so as to cause it to be a nuisance, or injurious or dangerous to health, renders the perpetrator liable, under s. 15, P.H.(L.)A., to a penalty of £5. If any person so repairs or constructs a drain as to cause it to be a nuisance, or injurious or dangerous to health, he is liable, under s. 42, P.H.(L.)A., to a penalty of £20.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878; R.P.P.A., 1876. In addition, Model By-laws.

The main Act coincides with the English P.H.A., 1875, but the definition of the term "contributory place" is somewhat different. It is not compulsory for the S.A. to enforce the drainage of undrained houses, though they are empowered to do so, and may also insist on the ventilation of drains. A R.S.A. may make by-laws with respect to the drainage of buildings, but may not directly enforce the drainage of new or rebuilt houses.

The R.P.P.A. applies to Ireland, but since it was passed before the constitution of S.As. in Ireland, there is some doubt how far its provisions concerning such authorities are in force.

Disposal of Sewage.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; R.P.P.A., 1876.

P.H.A., 1875.

S. 17.—Nothing in this Act shall authorise any L.A. to discharge sewage or filthy water into any natural stream or watercourse, canal, pond, or lake, until such sewage or filthy water has been purified.

Ss. 27–34.—For the purpose of disposal of sewage, a L.A. may construct works, may purchase or lease land or buildings, and may sell the sewage; but in the exercise of any of these powers must not create a nuisance. The L.A. is not bound to dispose of the sewage within its own district, but, in dealing with land for the disposal of sewage, must provide that all the sewage brought to such land shall be effectually disposed of without giving rise to a nuisance. The sanction of the L.G.B. is required before L.As. can commence such works outside their own district, if any objection is taken to their proposed action.

Ss. 233, 234.—The sanction of the L.G.B. is required to the borrowing of money above a certain amount by L.As. for the purpose of sewage works. The Board makes it a condition of their sanction that a sewage scheme shall provide for the sewage passing through land before being discharged into any river or stream to which the R.P.P.A. applies. The land required will be less if the sewage has previously been purified by chemical or mechanical means.

R.P.P.A., 1876.

S. 3.—No solid or liquid sewage matter may be passed into any stream unless it has been so passed before 1876, and then only if the best practicable and available means have been taken to render it harmless. This provision is impressed on S.As. by the R.P.P.A., 1893, which directs that if sewage enter a stream after passing in a channel vested in a S.A., the S.A. is deemed to have knowingly permitted the sewage to enter a stream.

S. 7.—A S.A. must afford facilities for the admission of manufacturing waste waters into their sewers, provided such waste waters are not of such a nature as to prejudicially affect the sewers, the disposal of sewage on land or otherwise at the outfall, or such as, from their temperature or otherwise, would be injurious from a sanitary point of view. Admission need not be granted if the sewers are only sufficient for the requirements of their district.

LONDON AND IRELAND.

The provisions as to disposal of sewage are the same as above.

Water Supply.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; Waterworks Clauses Acts, 1847, 1863; P.H.(Water)A., 1878; L.G.A., 1894; R.P.P.A., 1876, 1893; P.H.A.A.A., 1890 (adoptive); D.(A.)A. 1894; District Councils (Water Supply Facilities) Act, 1897.

P.H.A., 1875.

S. 51.—Any U.A. and any R.A. may provide a proper and sufficient supply of water for public and private purposes. They may—(1) construct and maintain waterworks, dig wells, and do any other necessary acts; (2) lease or hire waterworks, purchase, with consent of the L.G.B., waterworks or any water or right to take or convey water, either within or without their district, and any rights, powers, and privileges of any water company; (3) contract with any person for a supply of water.

S. 52.—But a L.A. may not proceed to construct waterworks in a district supplied by an authorised water company if such company is able and willing to supply water proper and sufficient for all reasonable purposes.

S. 53.—The L.A. is bound to give due notice to those concerned before constructing reservoirs, works, etc.

S. 54. The L.A. have the same powers as to carrying water mains through lands as they possess in regard to sewers (ss. 16 and 32, p. 496).

S. 55.—The supply of water must be pure and wholesome, and the pressure sufficient to carry it to the top of the highest houses within the district. It is not obligatory to provide a constant supply under pressure.

Ss. 56–64.—The L.A. have power to charge water rates and rents for the supply of water and the use of meters. There is a penalty provided for tampering with a water meter, and the L.A. is bound to keep such meters in good working order. All public cisterns, pumps, wells, etc., used for the gratuitous supply of water to the inhabitants of a district, vest in and are under the control of the L.A. The L.A. may require the owner of a house, which is reported by their surveyor to be without a proper supply of water, to obtain such a supply, provided that this can be done at a cost not exceeding the water-rate, or if there be no such rate, twopence per week, or such other sum as the L.G.B. fix on application of the L.A.

S. 65.—The L.A. may fix the terms upon which they will supply water for trade and manufacturing purposes, and may supply water free for public baths and wash-houses.

S. 68.—Heavy fines (£200, and £20 per day) are incurred by persons polluting any stream, pond, or place for water by gas washings or by any act connected with the making or supplying of gas.

S. 69.—A L.A. may proceed against any one polluting with sewage any watercourse within their jurisdiction, whether such pollution occur within or without their district.

S. 70.—If any person represent that the water in any well, tank, or cistern, public or private, or any pump supply used, or likely to be used, by man for drinking or domestic purposes, or for manufacturing drinks for the use of man, is so polluted as to be injurious to health, the L.A. may apply to a court of summary jurisdiction for an order to remedy the same. The court may make an order enjoining such procedure as will prevent injury to health, *e.g.* closing the well permanently or temporarily, or limiting the use of the water.

S. 97.—A house without a proper water supply may be in such a state as to be a nuisance, and if a court of summary jurisdiction consider it unfit for human habitation, the court may prohibit the use of such house until the condition is remedied.

S. 299.—If a L.A. make default in their duties as regards water supply, complaint may be made to the L.G.B., who may compel the L.A. to do their duty.

WATERWORKS CLAUSES ACT, 1847.

S. 53.—The owner or occupier of a dwelling-house within the district may demand a sufficient supply of water for domestic purposes if he provide service pipes and pay the water-rate.

The Waterworks Clauses Act, 1863, and certain of the provisions of the same Act, 1847, are incorporated in the P.H.A., s. 57.

WATERWORKS CLAUSES ACT, 1863.

S. 12.—A supply of water for domestic purposes shall not include a supply of water for cattle, or for horses, or for washing carriages, where such horses or carriages are kept for hire or by a common carrier, or a supply for any trade, manufacture, or business, or for watering gardens, or for fountains, or for any ornamental purpose. It therefore appears that a supply of water for private horses and carriages is included in a water supply for "domestic purposes."

S. 16.—The vendors of water may cut off the supply of any person who wastes, mis-uses, or contaminates the water, or consumes an undue amount.

P.H.(WATER)A., 1878.

This applies to all R.S.A., and the L.G.B. may, by order, confer similar powers to those of this Act upon any U.S.A.

S. 3.—Every R.S.A. must see that every occupied dwelling-house within the district has within a reasonable distance an available supply of wholesome water sufficient for the domestic purposes of the inmates, and may insist upon the owner obtaining such a supply if it be obtainable at a reasonable cost (*i.e.* a cost the interest on which at 5 per cent. would not exceed twopence or threepence per week), or, in his default, may provide it themselves, and recover expenses from the owner.

S. 6.—No house, newly built or rebuilt, may be occupied unless the owner has obtained a certificate from the S.A. that a sufficient supply of wholesome water is available within a reasonable distance.

S. 7.—The R.S.A. must from time to time satisfy themselves as to the condition of the water supply in their district, and have powers of entry for the purpose.

S. 9.—If the S.A. provide a standpipe for water supply, they may charge every dwelling within 200 feet for the water as if the supply were given on the premises; but not, however, upon such houses as have a good supply from another source within reasonable distance, unless water from the standpipe is used by the inmates.

L.G.A., 1894.

S. 8 (1, *e*).—A P.C. may utilise any well, spring, or stream within the parish, but so as not to interfere with the rights of others.

Ss. 16 and 19.—If the R.S.A. fail in their duty as regards water supply, the same proceedings can be taken against them as for similar default regarding sewers (p. 498).

R.P.P.A., 1876, 1893.

If a water supply be derived from a stream, the provisions of the R.P.P.A. assist in preventing its pollution (p. 563), as do also those of the P.H.A.A.A., 1890, s. 47 (if adopted), with regard to the fouling of streams by ashes, cinders, etc.

D.(A.)A., 1894.

It is unlawful to throw into any river, stream, canal, or other water, or into the sea within 3 miles from the shore, the carcase of any animal which has died of disease.

DISTRICT COUNCILS (WATER SUPPLY FACILITIES) ACT, 1897.

This Act gives facilities for the provision of a pure water supply in R.D. by allowing a charge to be fixed upon lands by their owners for any period not exceeding twenty-five years, in respect of the contributions of such owners to the expenses incurred by a R.D.C. in supplying water.

LONDON.

Acts Concerned.

Metropolis Water Acts, 1852, 1871; Water Companies (Regulation of Powers) Act, 1887; P.H.(L.)A., 1891; Companies Acts (of individual Water Companies). In addition, Model By-laws.

The L.G.B. controls the various water companies which supply London and its environs, and has power to approve or disapprove new sources of supply, to test periodically the purity of the water supplied, to inquire into complaints made by consumers as to the quality or quantity of the supply for domestic purposes, to approve regulations issued by the companies for the prevention of waste and contamination, and to order a constant supply if, in the opinion of the L.G.B., this would prevent prejudice to the health of the inhabitants.

The L.C.C. may require a constant water supply instead of an intermittent one to any district, provided certain conditions have been complied with as to the provision of proper fittings in over 80 per cent. of the houses in the district, and as to the promulgation of regulations of the water company, after approval by the L.G.B.

In London, a new house must not be occupied until the S.A. has granted a certificate that there is a sufficient and proper water supply. A water company, on cutting off the water supply to any inhabited dwelling, is required to give notice of the act to the S.A. of the district within twenty-four hours.

A S.A. must make by-laws enforcing cleanliness and freedom from pollution of tanks, cisterns, and other receptacles for drinking-water, or water for domestic purposes, or water used for manufacturing drinks.

The S.A. may apply for an order to close any well, tank, or cistern, and in such a case only require to prove that the water is "so polluted, or likely to be so polluted, as to be injurious or dangerous to health." This is a wider power than is possessed by provincial authorities under the P.H.A., 1875, s. 70.

Where the water-rate is payable by the landlord, a water company may not cut off the water supply from the occupier for non-payment of water rates.

The L.G.B. have approved Model By-laws to the effect that—(1) cisterns and tanks must be cleaned once in every six months, and at such other times as may be necessary to keep them clean; (2) every such tank, cistern, or receptacle is to be provided with a proper cover, and to be kept at all times properly covered. These duties fall on the occupier, except where two or more tenants or premises are entitled to a common use of these receptacles, in which case the owner is responsible.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878.

The S.A. may require all houses to be supplied with water at a reasonable cost, to be determined by the L.G.B.; no limit being prescribed, as in England. The S.A. may obtain powers to abstract water from a running stream or other source otherwise than by agreement, and the S.A. can compulsorily acquire water rights in order to provide water for drinking and domestic purposes. The S.A. cannot charge any one for water supplied by means of a public standpipe or street fountains.

In other respects the law in Ireland is similar to the P.H.A., 1875.

Cellar Dwellings.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875.

The prohibition of occupation of cellar dwellings applies both to urban and rural districts.

S. 71 renders it illegal to separately occupy, or suffer to be occupied, as a dwelling, any cellar (including any vault or underground room) built or rebuilt after the passing of the Act, or which was not lawfully so let or occupied at the time the Act was passed.

S. 72.—No cellar whatsoever may be let or occupied separately as a dwelling, unless it comply with the following requirements:—(1) The height must in every part be at least 7 ft.; 3 ft. of which must be above the level of the adjoining street. (2) An open area at least $2\frac{1}{2}$ ft. wide in every part, and 6 in. below the level of the cellar floor, must extend along the whole frontage. It may be crossed by steps, but not opposite the window. (3) The cellar must be drained effectually by a drain at least 1 ft. below the floor. (4) There must be proper sanitary accommodation, either water-closet, earth-closet, or privy, and an ashpit. (5) There must be a fireplace and chimney, and (6) an external window at least 9 sq. ft. in area clear of the sash frame, and made to open. The window of a back cellar let or occupied along with a front cellar must be external, but need only be 4 square ft. in area.

S. 73.—The penalty for letting or occupying a cellar contrary to these provisions is a fine not exceeding 20s. for every day after notice by the L.A.

S. 74.—Any cellar in which any person passes the night is deemed to be occupied as a dwelling.

S. 75.—Where, under this Act, two convictions have taken place within three months with regard to the same cellar, a court of summary jurisdiction may direct the temporary or permanent closure of the premises.

LONDON.

Acts Concerned.

P.H.(L.)A., 1891.

It is unlawful to let or occupy separately as a dwelling any underground room which was not so let or occupied before this Act came into force, unless it comply with the following conditions:—(1) The height must in every part be at least 7 ft., part of which must be above the level of the adjoining ground; this part may be 1 ft. only, provided that the outside area is 6 ft. wide, or that the width of the outside area is not less than the depth of the room floor below ground-level; in all other conditions 3 ft. of the height must be above the level of the adjoining ground. (2) A damp course must be in every wall, and any wall in contact with the soil must be effectually secured from damp. (3) There must be an open area along the whole frontage, at least 4 ft. wide in every part, and 6 in. below the level of the room floor. It may be crossed by steps, but not opposite a window. (4) Both the soil beneath the room and the area must be effectually drained. (5) Any hollow space below the room floor must be ventilated to the outer air. (6) Any drain under the room must be constructed of gas-tight pipe. (7) The room must be effectually secured against the rising of any effluvia or exhalation. (8) There must be proper water-closet and ashpit accommodation in a convenient place. (9) There must be effectual ventilation, and (10) a fire-place and chimney. (11) There must be one or more windows, opening directly to the open air, the window area being at least one-tenth of the floor area. The windows must open at the top, and at least half of each window must be capable of opening.

These requirements are also applicable to underground rooms occupied separately as dwellings prior to the passing of the Act; but the S.A. may in this case modify such of the requirements as would involve structural alterations. As in the P.H.A., 1875, two convictions may be followed by closure of the premises.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878.

The provisions are the same as in England and Wales.

Common Lodging-Houses.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; P.H.A.A.A., 1890. In addition, Model By-laws and Memorandum of L.G.B.

DEFINITION.—See p. 485.

P.H.A., 1875.

S. 76.—Every L.A., both urban and rural, must keep a register of all C.L.H. within their district, in which shall be entered the names and residences of the keepers of such C.L.H., the situation of every such C.L.H., the number of lodgers authorised under this Act by such L.A. to be received therein.

S. 77.—It is unlawful to keep an unregistered C.L.H.

S. 78.—Prior to registration, every C.L.H. must be inspected and approved by an officer of the L.A., and the character of the keeper must also be approved.

S. 79.—If required by the L.A., the words "Registered Common Lodging House" must be affixed on the outside of such house.

S. 80.—Every L.A. must make by-laws—(1) for fixing and from time to time varying the number of lodgers who may be received into a C.L.H., and for the separation of the sexes therein; (2) for promoting cleanliness and ventilation in such houses; (3) for the giving of notices and the taking of precautions in the case of any infectious diseases; (4) generally for the well ordering of such houses.

S. 81.—The L.A. can enforce a proper water supply to a C.L.H., if such be deficient and can be procured at a reasonable rate. The L.A. may remove the C.L.H. from the register until a proper water supply is procured.

S. 82.—The keeper of a C.L.H. must limewash the walls and ceilings in the first week of April and October in every year.

S. 83.—The L.A. can require the keeper of a C.L.H. in which beggars or vagrants are received, to report every person who resorted to such house during the preceding day or night. Schedules for the return shall be furnished by the L.A.

S. 84.—The keeper must give immediate notice to the M.O.H. and to the poor-law relieving officer of any person in his C.L.H. who is ill of fever or any infectious disease.

S. 85.—The keeper and every other person in charge must give free access at all times to any officer of the L.A. Penalty for refusal, £5.

S. 88.—Three convictions against a keeper of a C.L.H. for contravening any of the provisions of this Act entitle the court to suspend him from keeping a C.L.H. for a period not exceeding five years, unless he obtain the licence of the L.A.

S. 124.—The L.A. has power to remove to hospital any person suffering from dangerous infectious disease in a C.L.H. (p. 520).

P.H.A.A.A., 1890, Part III. (Adoptive).

S. 32.—If the keeper of a C.L.H. fail to give the notice required by s. 84, P.H.A., 1875, he is liable to a penalty of 40s., and a daily penalty of 5s.

MODEL BY-LAWS.

Number of Lodgers.

A maximum number of lodgers to be accommodated in the whole C.L.H. and in each room is fixed by the S.A., and the keeper must not allow this number to be exceeded. The S.A. may vary the number from time to time, and a notice showing the number allowed must be exhibited in each room. The space per head allowed is, as a rule, not less than 300 cubic ft. for each adult or two children.

Separation of Sexes.

In general, no person above 10 years of age must occupy the same sleeping-room as persons of the opposite sex. Rooms may be set apart for the sole use of married couples, to the exclusion of other persons over 10 years of age, on condition that every bed is screened off. No bed must be occupied by more than one male above 10 years of age.

Cleanliness of Premises, etc.

The yards, etc., must be kept clean and in good order, all floors swept daily and washed once a week; all windows, painted surfaces, and fittings of wood, stone, or metal kept clean. Closets must be kept clean and in good working order. Ashpits must be kept clean, and no filth or wet refuse deposited in ashpits for dry refuse. Windows must be opened fully for an hour in the morning and an hour in the afternoon, except in case of very bad weather, or of occupation of the room by a sick person or other sufficient cause. Beds must be stripped of clothes and exposed freely to the air for an hour each day, and must not be reoccupied within eight hours after being vacated. All refuse and slops must be removed each day before 10 a.m., and all utensils daily cleansed. Every sleeping-room must be provided with sufficient bedsteads, beds, bedclothes, and utensils for the use of the maximum number of lodgers allowed to be therein. Sufficient suitable basins, water, and towels must be provided for the use of lodgers, and must be kept clean and renewed as required.

Infectious Diseases.

The keeper, on finding that any lodger is suffering from an infectious disease, must at once take all necessary precautions. No person, except a relative or attendant, must occupy the same room as the sick person. If the patient is removed to hospital by the S.A., the keeper must afford all facilities for removal, must adopt all precautions directed by the M.O.H., and must, if required, temporarily cease to receive lodgers into any infected room. At the end of the case, by removal, recovery, or death, the keeper must at once give notice to the M.O.H., and must cleanse and disinfect every part of the infected rooms and their contents, and in doing so comply with all instructions of the M.O.H. When the cleansing and disinfection are completed, he must give notice to the M.O.H., and must not receive any lodger into the rooms in question until two days after such notice has been given.

Exhibition of By-laws.

A copy of the by-laws in force with respect to C.L.H., supplied by the S.A., must be conspicuously exhibited in the house, and must not be concealed, altered, obliterated, or injured.

The S.A. should append to such copy of the by-laws the provisions of the P.H.A. applicable to C.L.H., which are not contained in the by-laws.

MEMORANDUM OF L.G.B.

This deals with the conditions which should be fulfilled by a C.L.H. before the S.A. should register it. A C.L.H. should (1) possess the conditions of wholesomeness needed for dwelling-houses in general; and (2) should have arrangements fitting it for its special purpose of receiving a number of lodgers.

Inside walls should not be papered. Every registered room should have special means of ventilation, by chimney if possible, and a window opening freely and directly upon the open air.

There should be kitchen and day-room accommodation apart from the bedrooms. Rooms partially underground should not be registered as sleeping-rooms. There should be a supply of pure water, allowing at least 10 gallons per head per day for the maximum number of inmates. There should be one closet for every twenty registered lodgers. The washing accommodation should, wherever practicable, be in a special place, and not in the bedrooms, the basins for personal washing being fixed, trapped, and fitted with disconnected waste pipes.

LONDON.

Acts Concerned.

C.L.H.A., 1851, 1853; P.H.A., 1875. In addition, Model By-laws and Memorandum of L.G.B.

The L.C.C. controls the C.L.H. in London, and the provisions of the C.L.H.A. are essentially the same as in the P.H.A., 1875, which are given above.

In the City of London the Commissioners of Sewers are the S.A., and the law is the P.H.A., 1875.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878. In addition, Model By-laws and Memorandum of L.G.B.

The definition of the C.L.H. in Ireland is somewhat different from that in England, and is as follows:—"A house in which, or in any part of which, persons are harboured or lodged for hire for a single night, or for less than a week at a time."

The law regarding C.L.H. is like that in England; but if the keeper of a C.L.H. fail to do the obligatory limewashing at the stated seasons, the S.A. may do it, and recover the cost. The S.A. must remove from the register any C.L.H. not having a proper water supply. The L.G.B. of Ireland may issue model by-laws resembling those of the L.G.B. of England.

Houses Let in Lodgings.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; H.W.C.A., 1885; Merchant Shipping Act, 1894.
In addition, Model By-laws.

DEFINITION (p. 485).

P.H.A., 1875.

S. 90.—The L.G.B. may empower any L.A. to make by-laws for houses let in lodgings as regards the following matters:—(1) For fixing, and from time to time varying, the number of persons who may occupy such house or part of a house, and for the separation of the sexes therein. (2) For the registration and inspection of such houses. (3) For enforcing drainage, the provision of privy accommodation, cleanliness and ventilation of such houses. (4) For cleansing and limewashing at stated seasons, and for the paving of yards. (5) For giving notice of infectious disease, and for the taking of precautions in such cases.

Houses in which the rooms are let at or above a certain weekly rental (to be determined by the L.A.) are usually exempted from the operation of these by-laws.

H.W.C.A., 1885.

S. 8 confers on the L.A. the power of making these by-laws; an order of the L.G.B. is not required.

MERCHANT SHIPPING ACT.

The L.A. whose district includes a port may, with approval of the Board of Trade, make by-laws relating to seamen's lodging-houses, and providing for their licensing, inspection, sanitary condition, control, and proper management.

MODEL BY-LAWS.

A lodging-house is exempt from the operation of these by-laws if the rateable value exceed . . . and the rent payable by each lodger for unfurnished rooms be not less than . . . per week, and for furnished rooms not less than . . . per week.

The Model By-laws make no provision for varying the number of lodgers allowed, or for separation of the sexes.

CUBIC SPACE.

In rooms used exclusively as sleeping-rooms, 300 cubic ft. of air space must be provided for each person above 10 years of age, and 150 cubic ft. for each person under that age. In rooms used as sleeping-rooms, but not exclusively so, 400 cubic ft. of air space must be provided for each person above 10 years of age, and 200 cubic ft. for each person under that age.

The lodger, as well as the landlord, must see that this regulation is not infringed.

RETURNS BY THE LANDLORD.

If required by the L.A., the landlord must furnish returns as to the number of rooms in the house, the number of rooms let in lodgings or occupied by members of more than one family, the manner of use of each room, the number, age, and sex of the occupants of each sleeping-room, the full name of the lessee of each room, and the rent payable by each lessee.

Inspection.

Free access must be allowed at all times to officers of the L.A., the M.O.H., surveyor, or I.N.

Closet Accommodation.

Sufficient water-closet, earth-closet, or privy accommodation must be provided in the proportion of one closet to every 12 persons, and must be kept clean and in good working order. An ashpit must also be provided. The Model By-laws with regard to these sanitary conveniences (p. 493) may be inserted here.

Cleanliness of Premises and Rooms.

The landlord must cleanse the whole premises at least once a year at a stated season, and limewash the walls and ceilings, or otherwise cleanse and paint them. The landlord must also keep any yard or open space clean and in good order; the yard must be paved, and surface drainage provided for it, ending in a trapped gully grating. The lodger must have the floor of his room swept daily and washed once a week, and the windows and other fixtures must be kept clean. All solid or liquid filth and refuse must be removed daily from the room, and all receptacles thereof cleansed. No animal must be kept upon the premises in such manner as to render the premises filthy. All cisterns or other receptacles for water must be kept clean.

Ventilation.

The landlord must see that the means of ventilating all parts of the house are kept in efficient condition. The tenant must see that the window of his sleeping-room is kept open for an hour in the forenoon and an hour in the afternoon of each day, unless this be prevented by very bad weather, occupation of the room by a sick person, or other sufficient cause.

Infectious Diseases.

The landlord must give notice at once to the M.O.H. if he is aware that any person in the house is ill of an infectious disease, and any lodger must likewise give notice to the M.O.H., and also to every lodger in the house, if he has reason to believe that an occupant of his room is ill of an infectious disease. Both landlord and lodger must assist in the removal to hospital of such sick person if a justice's order has been obtained for the removal, and both must adopt all precautions directed by the M.O.H.

Any part of the house not in the sole use of one tenant must be kept clean by the landlord; the tenant is responsible for the rooms, etc., of which he has the sole use.

Structural repairs, the provision and efficiency of closets and of ventilation, are the province of the landlord.

LONDON.

ACTS CONCERNED.

P.H.(L.)A., 1891; Merchant Shipping Act, 1894. In addition, Model By-laws.

The S.A., in the City the Commissioners of Sewers, in the administrative county of London the L.C.C. and Borough Councils, must make and enforce by-laws with the same scope as those referred to in s. 90, P.H.A., 1875.

The L.C.C. is the authority entitled, under the Merchant Shipping Act, to make by-laws for seamen's lodging-houses.

IRELAND.

ACTS CONCERNED.

P.H.(I.)A., 1878; H.W.C.A., 1885; Merchant Shipping Act, 1894. In addition, Model By-laws.

The law in Ireland on this subject is not without ambiguity.

The P.H.(I.)A. has a section corresponding to s. 90 of the P.H.A., 1875, and the H.W.C.A., 1885, applied to Ireland, so that the law in Ireland from 1885 to 1890 was the same as in England: in 1890 a new H.W.C.A. was passed, it left s. 8 of the 1885 Act in force, but repealed other portions, including the clause applying the Act to Ireland.

The S.A. can therefore make by-laws on this subject with the authority of the L.G.B., but it is doubtful how far they may do so without that authority.

As to seamen's lodgings, the same provisions apply in Ireland as in England.

Nuisances.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; H.W.C.A., 1885; F.&W.A., 1901; C.M.R.A., 1887; Q.F.A., 1887; B.W.A., 1893. In addition, Model By-laws, 1899, under H.W.C.A., 1885.

DEFINITION.—See p. 486.

CLASSIFICATION OF NUISANCES.—

(*a*) AT COMMON LAW.
- (*a*) *Public.—Example*, Discharge of large quantities of steam into the open air.
- (*b*) *Private.—Example*, Noise of animals kept, *e.g.* in a slaughter-house.

(*b*) AT STATUTE LAW. — Under P.H.A. and above Acts. A statutory nuisance is either injurious to health or liable to become so, *i.e.* dangerous to health.

P.H.A. 1875.

S. 91.—The following are specified as nuisances and are liable to be dealt with summarily:—

1. "Any premises in such a state as to be a nuisance, or injurious to health." Note the definition of premises (p. 486), and that "such a state

as to be a nuisance, or injurious to health," may arise from many different defects. The site, the construction, the want of ventilation and sunlight, the absence of a proper water supply or drains, or any other non-hygienic condition may render premises a nuisance.

2. "Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit so foul or in such a state as to be a nuisance or injurious to health." Note the definition of drain (p. 485), and compare the provisions of ss. 41, 44, and 47 of this Act (see p. 490).

3. "Any animal so kept as to be a nuisance, or injurious to health." Compare s. 44 (p. 490) and s. 47 (p. 491).

4. "Any accumulation or deposit which is a nuisance, or injurious to health." "No penalty is to be imposed on any person in respect of any accumulation or deposit necessary for the effectual carrying on of any business or manufacture, if it be proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health."

5. "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family." Overcrowding is not specifically defined in the Act; it is left to the decision of the M.O.H. in each case, but in forming his opinion he is guided by the space allowed per head in the Model By-laws as to houses let in lodgings (p. 509).

6. "Any factory, workshop, or workplace (α) not kept in a cleanly state, or (β) not ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein that are a nuisance, or injurious to health, (γ) or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein."

This section applies to factories and workshops which are not subject to the F.&W.A. in the matters of cleanliness, ventilation, and overcrowding, and which are under the L.A. in regard to these particulars. Confer as to the F.&W.A. (p. 568), and note that an inspector under this Act is bound to inform the L.A. if he observe any contravention in a workshop of the provisions of the P.H.A.

This section applies also to other buildings, such as schools.

7. "Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dye-house, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever, and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance." The court must hold that no nuisance is created within the meaning of this Act, if it is satisfied that "such fireplace or furnace is constructed in such manner as to consume, as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof."

Note that in this subsection the words injurious to health do not appear, and the emission of the smoke is the nuisance. Owing to the proviso quoted above, most convictions for smoke nuisance are obtained for the voluminous issue of black smoke. Note that smoke of other colours is not mentioned, and to prove a nuisance from brown or yellow smoke, it would be necessary also to prove that there was faulty construction of the furnace or neglect in stoking. Compare also the article on Smoke Prevention (p. 302).

S. 92.—It is the duty of the L.A. to inspect their district for the detection of nuisances, and to enforce the provisions against nuisance whether contained in this Act or any local Act.

S. 93.—Information of nuisance may be made to the L.A. by—(1) any aggrieved person; (2) any two householders in the district; (3) any officer of the L.A.; (4) the relieving officer; or (5) any constable or officer of police of the district.

S. 94.—If satisfied that a nuisance exists, the L.A. shall serve a notice upon the person responsible, or failing him, the owner or occupier of the premises upon which the nuisance arises, requiring him to abate the same within a specified time, and to execute such works and do such things as may be necessary: provided (*a*) that where the nuisance arises from the want or defective construction of any structural convenience, or where there is no occupier, notice shall be served on the owner; (*b*) that where the person causing the nuisance cannot be found, and it is clear that the nuisance does not arise or continue by the act, default, or sufferance of the owner or occupier of the premises, the L.A. may themselves abate the same.

S. 95.—Non-compliance with the notice is followed by complaint before a justice by the L.A.: the justice thereupon issues a summons to the person to appear before a court of summary jurisdiction.

S. 96.—The court may make an order requiring compliance with the notice, or prohibiting recurrence of the nuisance, or directing execution of any necessary works, and may impose a penalty not exceeding £5.

S. 97.—If a nuisance is such as to render a house unfit for human habitation, the court may prohibit the use of the house until it is rendered fit.

Ss. 98–100.—Penalties are provided for disobedience of the order of the court, and for lack of diligence in the execution thereof. If the order of the court be neglected, the L.A. may do the work themselves, and recover the cost in a summary manner; and if those responsible for the nuisance cannot be found, the court may order the L.A. to do the work.

Ss. 102, 103.—The L.A. has powers of entry for its officers to carry out the provisions of the Act, and may obtain an order from a justice in the event of the refusal of admission.

S. 105.—Any person aggrieved by a nuisance, any inhabitant of the district, or the owner of any premises, may complain of the existence of a nuisance to a justice, who may take the same proceedings as if the complaint had been made by the L.A.

S. 106.—The L.G.B. may, if the L.A. default in their duty regarding nuisances, appoint a police officer to do the duty, but such police officer only has power of entry with consent or by justice's warrant.

S. 108.—The L.A. have power to proceed against persons outside their own district when such persons are responsible for nuisances arising outside the district, but causing nuisance within the district.

S. 109.—An overcrowded house is a nuisance under s. 91; and if two convictions for overcrowding take place within three months in regard to any house, a court of summary jurisdiction may, on the application of the L.A., direct the closing of the house for any period which the court may deem necessary.

S. 110.—The portion of this Act relating to nuisances applies to any ship or vessel lying in any river, harbour, or other water within the district of a L.A., as if the ship were a house; if in any other water, it is located in such district as the L.G.B. may prescribe, and in the absence of such prescription, in the nearest sanitary district. The master of the ship is regarded as the occupier, and the section does not apply to His Majesty's ships or to the ships of foreign governments.

Orders of Court regarding nuisances are of three kinds—(*a*) abatement; (*b*) prohibition; (*c*) closure. With the first two of these, a penalty may be imposed, while the third relates to a house rendered unfit for habitation.

These are the main sections of this Act relating to nuisances, but nuisance may arise in connection with subjects dealt with in other parts of the Act, such as sewers, sewage, drains, and sanitary conveniences of all kinds, refuse, filth, snow, keeping of swine, stagnant water, offensive trades, etc.

These either have been or will be dealt with in the exposition of the Act.

H.W.C.A., 1885.

S. 9.—(1) A tent, van, shed, or similar structure used for human habitation, which is in such a state as to be a nuisance, or injurious to health, or which is so overcrowded as to be injurious to the health of the inmates, whether or not members of the same family, is a nuisance within the meaning of s. 91, P.H.A., and may be dealt with accordingly.

(2) A S.A. may make by-laws for promoting cleanliness in, and the habitable condition of, tents, vans, and sheds, and similar structures used for human habitation, and for preventing the spread of infectious disease by the persons inhabiting the same, and generally for the prevention of nuisances in connection with the same.

(3) Authorised officials have powers of entry to investigate contraventions of this Act, or any by-laws under this Act.

The section does not apply to any tent, van, or shed, or structure erected or used by any portion of His Majesty's naval or military forces.

Model by-laws have been issued by the L.G.B. in regard to this section (p. 558).

F.&W.A., 1901.

Every workshop and workplace within the meaning of the P.H.A. must be kept free from effluvia arising from any drain, water-closet, earth-closet, privy, urinal, or other nuisance, and unless so kept shall be deemed to be a nuisance liable to be dealt with summarily under the law relating to public health.

C.M.R.A., 1887.

Abandoned coal mines must be fenced; and any shaft or side entrance to a mine not fenced and within 50 yards of any highway, road, footpath, or place of public resort, or which is in open or unenclosed land, is declared to be a nuisance under s. 91, P.H.A.

Q.F.A., 1887.

Dangerous (unfenced) quarries within 50 yards of a public highway are also deemed nuisances under s. 91, P.H.A.

B.W.A., 1893.

Barbed wire adjacent to a highway and liable to injure persons or animals lawfully using such highway is a nuisance under s. 91, P.H.A.

LONDON.

ACTS CONCERNED.

P.H.(L.)A., 1891; H.W.C.A., 1885; F.&W.A., 1901; C.M.R.A., 1887; Q.F.A., 1887; B.W.A., 1893. In addition, Model By-laws.

P.H.(L.)A., 1891.

Under this Act the L.A. in London are better equipped for dealing with nuisances than L.As. in the provinces under the P.H.A., 1875. The definition of a nuisance is extended so as to include not only conditions injurious, but conditions dangerous to health, and among the specified nuisances is included any cistern, water-closet, or other sanitary convenience so foul or in such a state as to be a nuisance, or injurious or dangerous to health. Premises devoid of water fittings are also a nuisance. Information to the S.A. of the existence of a nuisance may be given by any person, and must be given by the relieving officer, and every officer of the S.A. Written intimation of the existence of a nuisance and its need for abatement must be given by the S.I. to any person who may be required to abate it. This provision enables the author of a nuisance to abate it before the S.A. proceed to serve him with a notice. A notice from the S.A. requiring the abatement of a nuisance need not specify the works to be done for the purpose, as is the case in the P.H.A., 1875. There are some other differences, and the penalties are greater than in the P.H.A., 1875. The faulty construction or repair of a closet, or the wilful injury of it, so as to cause it to be a nuisance, is penalised. The S.A. must make by-laws for the prevention of nuisances.

Every furnace used for working steam-engines, or in buildings used for trade or manufacture, must be so constructed as to consume and burn its own smoke. In other respects the provisions of this Act closely resemble those of the P.H.A., 1875.

H.W.C.A., 1885, s. 9.
F.&W.A., 1901.
C.M.R.A., 1887.
Q.F.A., 1887.
B.W.A., 1893.
MODEL BY-LAWS.

These apply to London as to England and Wales.

IRELAND.

ACTS CONCERNED.

P.H.(I.)A., 1878; H.W.C.A., 1885, s. 9; F.&W.A., 1901; C.M.R.A., 1887; B.W.A., 1893. In addition, Model By-laws.

The law in Ireland is practically the same as in England, but the Quarry Fencing Act does not apply to Ireland.

Note the position of the H.W.C.A., 1885, in Ireland, as explained p. 511.

Offensive Trades.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875. In addition, Model By-laws.

P.H.A., 1875.

S. 112.—The establishment of any offensive trade within the district of an urban authority without their consent, is forbidden under a penalty of £50, and any person carrying on such a business is liable to a penalty of 40s. a day. The offensive trades specified are those of blood, bone, soap, and tripe boiler, fellmonger, and tallow-melter, and any other noxious or offensive trade, business, or manufacture. In order to include any other trade among those subject to this section, it is necessary to prove (*a*) that it is ejusdem generis with the specified trades, *i.e.* that the materials used are the same as, or similar to, those employed in the above six trades, or that in its nature the trade is offensive, dealing with noxious or offensive materials, which may give rise to nuisance, even though the trade be properly conducted; or (*b*) that it is, or must be, carried on in such a manner as to be noxious or offensive. The L.G.B. may confer on rural authorities similar powers to those possessed by urban authorities under this and the following sections.

S. 113.—An U.S.A. may make by-laws with respect to such trades as have been established with their consent, in order to prevent or diminish the noxious or injurious effects thereof.

S. 114 deals with nuisance, or injury to health, arising from effluvia given off from trade premises. The M.O.H., two legally qualified medical practitioners, or ten inhabitants of the district of an U.S.A., may certify the existence of the nuisance, and on this certificate the S.A. must take proceedings before a justice, who may summon the person by whom or on whose behalf the trade is carried on, to appear before a court of summary jurisdiction. There is no penalty if it be proved to the court that the best practicable means for abating such nuisance, or preventing or counteracting such effluvia have been taken. The following premises are specified, candle-house, melting-house, melting-place, soap-house, slaughter-house, any building or place for boiling offal or blood, or for boiling, burning, or crushing bones, or any manufactory, building, or place used for any trade, business, process, or manufacture causing effluvia.

S. 115.—The same powers apply as regards a nuisance arising from trade premises outside the district, but affecting the inhabitants of the urban district.

MODEL BY-LAWS.

The L.G.B. have issued model by-laws for each of the six trades specified as offensive in the P.H.A., and also for each of seven other trades which may be regarded as noxious or offensive.

The trades to which these by-laws refer are those of—

Blood-boiler.	Gut-scraper.
Bone- ,,	Fat-melter or fat-extractor.
Soap- ,,	Glue maker.
Tripe- ,,	Size maker.
Fellmonger.	Tanner.
Tallow-melter.	Leather-dresser.
Blood-drier.	

These by-laws need not be given in detail, each is adapted to its particular trade, and all state penalties, and are directed to obtain the following desiderata :—

(*A*) Prevention of Effluvia.

(1) By proper storage of offensive materials. (2) By the adoption of the best practicable means of rendering innocuous any vapours emitted during any process or manufacture. Four alternative means are allowed for this object, namely, (α) discharge into the external air in such a manner and at such a height as to admit of diffusion of the vapour without noxious or injurious effects, or (β) direct passage through a fire, or (γ) passage into a suitable condensing apparatus, or (δ) passage through a condensing apparatus, and then through a fire.

(*B*) Efficiency of Drainage.

All drains to be kept in good working order.

(*C*) Cleanliness.

Floors and walls to be impervious and non-absorbent of filth, and to be swept, washed, scraped, or otherwise cleansed daily. Prompt removal of refuse. Vessels, utensils, tables, and implements to be thoroughly cleansed, daily if necessary.

(*D*) Free Access for Purposes of Inspection.

Admission at all reasonable times to the premises of the M.O.H., the I.N., or the surveyor of the S.A., or any special committee of the S.A., is enjoined.

The following special points should be noted with regard to particular trades :—

The bone-boiler must cool all liquid refuse before discharging it into any drain.

The soap-boiler must render vapours innocuous by one of the last three methods mentioned above.

The tripe-boiler must limewash the walls, ceilings, etc., four times in every year, and must provide non-absorbent receptacles furnished with closely-fitting covers for conveying refuse of all kinds from his premises. Further, he must cool all liquid refuse before discharging it into any drain.

The fellmonger must provide tightly-covered receptacles for filth, must renew the water sufficiently often in every washing or soaking tank, and empty the tanks at least once a day, and must promptly remove waste lime in covered receptacles.

The tallow-melter must limewash internal surfaces twice a year.

The gut-scraper must frequently each day during work sweep and sprinkle with an effective deodorant the floors and pavements, and must daily collect and remove refuse in proper closed receptacles containing a sufficient quantity of deodorant solution. Walls and ceilings are to be limewashed four times a year, and utensils, etc., cleansed daily with deodorant solution.

The fat-melter has obligations similar to those of a tallow-melter.

The glue maker must, as far as possible, dry, or subject to the action of a sufficient quantity of milk of lime, any materials about to be stored. Scutch or refuse must not be stored longer than forty-eight hours, and during that time must be kept in a proper shed or in closed receptacles. Waste lime must forthwith be removed in covered vessels. Internal surfaces must be limewashed once a year.

The size maker is under the same obligation as the glue maker.

The tanner must promptly remove waste lime in covered vessels, and must scrape and limewash internal surfaces of the building twice a year.

The leather-dresser must thoroughly cleanse, at least once a week, every receptacle for "puer," must promptly remove waste lime in covered vessels, and must scrape and limewash internal surfaces of the building twice a year.

LONDON.

Acts Concerned.

P.H.(L.)A., 1891. In addition, Model By-laws.

The L.C.C., and in the City the Commissioners of Sewers, are the authorities for regulating offensive trades in London, and the law is somewhat different from the P.H.A., 1875. No one is allowed to establish anew in London the business of a blood-boiler, bone-boiler, manure manufacturer, soap-boiler (if the soap be made from animal fats other than olein), tallow-melter, or knacker. The authority may permit the establishment of a soap-boiling business if the fat used is vegetable fat or oil, or such an animal fat or oil as contains exclusively olein. With the consent of the C.C., the trade of a fell-monger, tripe-boiler, or slaughterer of cattle or horses, or other offensive trade, specified by the C.C. and approved by the L.G.B., may be established in London. Removal to new premises, extension of existing buildings, and the recommencement of work after an interval of nine months, are all regarded as "establishing anew" a business.

The L.C.C. may make by-laws regulating the conduct of offensive trades, and prescribing the construction required in buildings for such trades. Further, they may licence slaughter-houses, knackers' yards, and cow-houses, and renew such licences annually. The removal, storage, and disposal of house and street refuse by a S.A. is declared to be an offensive trade, and the C.C. is the superior authority to whom is entrusted the duty of preventing S.As. causing nuisance in the conduct of such trade. Otherwise the law as to offensive trades is the same as the P.H.A., 1875. The Model By-laws have been referred to above.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878. In addition, Model By-laws.

Offensive trades in Ireland must be regulated by the U.S.A., but a R.S.A. cannot acquire such urban powers as English R.As. can do. The offensive trades in Ireland are the same as in England, with the addition of the business of gut manufacturer. It is compulsory for an U.S.A. to make by-laws relating to offensive trades under the approval of the L.G.B. The requirements of the law as to offensive trades are analogous to those in England.

Unsound Food.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; P.H.A.A.A., 1890 (Adoptive); M.F.F.C.A., 1847.

P.H.A., 1875.

S. 116.—Any M.O.H. or I.N. may at all reasonable times inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man. The onus of proof that the particular article was not exposed or deposited for any such purpose, or was not intended for the food of man, rests with the person charged. If any such article appears to the M.O.H. or I.N. to be diseased, or unsound, or unwholesome, or unfit for the food of man, he may seize and carry away the same himself, or by an assistant, in order that a justice may deal with it. Note that this section applies to living animals, if intended for human food, as well as to carcases; but that food after being sold cannot be "seized" under this section, and that many common articles of food are not specified in the section.

S. 117.—The justice may condemn the unsound food, and order it to be destroyed or so disposed of as to prevent it being exposed for sale or used for the food of man, and he may inflict as penalty a fine not exceeding £20, or a term of imprisonment not exceeding 3 months. The onus of proof that the unsound food was not intended for the food of man rests with the defendant.

S. 118 provides a penalty of £5 for obstructing or impeding the M.O.H., or I.N., in the execution of his duty.

S. 119.—The M.O.H., or I.N., or other officer of the S.A., may obtain a search warrant from a justice by complaint on oath, and there is a penalty of £20 for hindering either officer in the execution of his duty under such warrant.

P.H.A.A.A., 1890.

S. 28.—This extends the above sections of the P.H.A., 1875, so as to apply to "all articles intended for the food of man, sold or exposed for sale, or deposited in any place for the purposes of sale or of preparation for sale." The justice may condemn any such article, and order it to be destroyed if satisfied that it is diseased, unsound, unwholesome, or unfit for the food of man, even if it has not been formally seized under s. 116.

M.F.F.C.A., 1847.

In markets and fairs under the control of the U.S.A., the sale of unwholesome meat or provisions is subject to similar restrictions under s. 15 of this Act, which is incorporated with the P.H.A., 1875. If the market or fair does not belong to the S.A., the clause does not apply unless a local Act incorporates the M.F.F.C.A. A S.A. may make by-laws under s. 42 to prevent the sale of unwholesome provisions.

LONDON.

Acts Concerned.

P.H.(LONDON)A., 1891.

The London Act is more comparable to the P.H.A.A.A. than to the P.H.A., 1875, but goes even further in its restrictions. Thus the fine limit is raised to £50, and that of the term of imprisonment to six months.

The previous vendor of the food is made liable, and on a second conviction within a year for obstructing any officer in his duty, imprisonment may be the penalty instead of the usual fine.

Lastly, the S.A. must remove unsound food, as if it were trade refuse, on being served with a written notice from its possessor requesting removal.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878; P.H.A.A.A., 1890.

By the former Act, butter is included in the articles specified in clauses similar to those of the English Act.

An U.A. may make by-laws, applicable to markets and fairs belonging to it, for the prevention of the sale of unsound food.

The chief provisions as to unsound food are the same as in England.

Infectious Disease and Hospitals.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875, 1896; I.D.N.A., 1889; I.D.N.(Extension)A., 1899; I.D.P.A., 1890; I.H.A., 1893; Merchant Shipping Act, 1894; C.D.(A.)A., 1878 and 1886; F.&W.A., 1901. In addition, Memorandum of the L.G.B. as regards School Children, 1890; Education Code, art. 98; Regulations of the L.G.B.; Orders of the L.G.B.

P.H.A., 1875.

S. 120.—On the certificate of the M.O.H., or of any other medical practitioner, that the cleansing and disinfecting of any house or part thereof, and of any articles therein likely to retain infection, would tend to prevent or check infectious disease, the L.A. must give written notice to the owner or occupier, requiring him to cleanse and disinfect the same within a specified time. A daily penalty not exceeding ten shillings is imposed for every day of default, and the L.A. must themselves cleanse and disinfect, either in case of default or in case of poverty or other cause rendering the owner or occupier unable to do so effectually. The consent of the owner or occupier is in the latter case necessary.

S. 121.—A L.A. may order the destruction of any bedding, clothing, or other articles which have been exposed to infection from any dangerous infectious disorder, and may give compensation for the same.

S. 122.—A L.A. may provide a proper place, apparatus, and attendants for disinfection of infected articles, and may disinfect free of charge.

S. 123.—A L.A. may provide and maintain ambulances, and may pay the cost of conveyance of an infected person to hospital or other destination.

S. 124.—Where any suitable hospital is provided within the district or within a convenient distance, any justice may, on the certificate of a medical practitioner, and with the consent of the hospital managers, order the removal to hospital of any person who is suffering from any dangerous infectious disorder and is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel. The L.A. may also, on a like certificate and with the like consent, remove any person so suffering who is lodged in any C.L.H.

S. 125.—A L.A. may make regulations (which require the approval of the L.G.B.) for removing to hospital, and detaining there as long as may be necessary, any persons brought within their district by any ship or boat and infected with a dangerous infectious disorder.

S. 126.—A person suffering from any dangerous infectious disorder may not wilfully expose himself, without proper precautions against spreading the disorder, in any street, public place, shop, inn, or public conveyance, nor enter any public conveyance without previously notifying to the owner, conductor, or driver thereof that he is so suffering. A person in charge of an infectious person may not so expose the sufferer. No person may give, lend, sell, transmit, or expose, without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection from any dangerous infectious disorder; but this does not apply to the transmission with proper precautions of any such articles for the purpose of having them disinfected. An infectious person using a public conveyance without the prescribed notice is liable not only to a fine, but to the costs of disinfection of the conveyance. Contravention of any provision of this section involves a fine not exceeding £5.

S. 127.—The owner or driver of a public conveyance must immediately provide for the disinfection of such conveyance after it has to his knowledge conveyed any infectious person, but he need not convey any person so suffering until he has been paid a sum sufficient to cover the cost of such disinfection.

S. 128.—Any person who knowingly lets for hire any house, room, or part of a house in which any person has been suffering from dangerous infectious disorder, without having it and its contents disinfected to the satisfaction of a medical practitioner, as testified by a certificate, is liable to a penalty of £20. This section applies to innkeepers as well as others.

S. 129.—Any person letting, or showing for the purpose of letting, for hire any house or part of a house, who, on being questioned as to the fact of there being, or within six weeks previously having been, therein any person suffering from a dangerous infectious disorder, knowingly makes a false answer to such question, is liable to fine or imprisonment with or without hard labour.

S. 130.—The L.G.B. may from time to time make, alter, and revoke such regulations as to the said L.G.B. may seem fit, with a view to the treatment of persons affected with cholera or any other epidemic, endemic, or infectious disease, and for preventing the spread of cholera and such other diseases, as well on the seas, rivers, and waters of the United Kingdom, and on the high seas within 3 miles of the coast thereof, as on land; and may declare by what authority or authorities such regulations shall be enforced and executed.

Ss. 131–133.—Any L.A. may build or contract for the use of hospitals, or may make arrangements with the managers of any hospital for the reception therein of the sick inhabitants of their district. Two or more L.As. may combine for this purpose. The expense of maintenance of non-pauper patients may be recovered from such patients; and the L.A. may, with the sanction of the L.G.B., themselves provide or contract for a temporary supply of medicine and medical assistance for the poor of their district.

S. 134.—The L.G.B. may, whenever any part of England appears to be threatened with, or is affected by, any formidable epidemic, endemic, or infectious disease, make, and may from time to time alter and revoke, regulations for any of the following purposes,—namely, for the speedy interment of the dead, for house to house visitation, and for the provision of medical aid and accommodation, for the promotion of cleansing, ventilation, and disinfection, and for guarding against the spread of disease; and may, by order, declare all or any of the regulations so made to be in force for any period within the whole or any part of the district of any L.A., and to apply to any vessels, whether on inland waters or on arms or parts of the sea within the jurisdiction of the Lord High Admiral of the United Kingdom, and may, by subsequent order, abridge or extend such period.

Ss. 136, 137.—The L.As. are bound to carry out the regulations made under s. 134, are invested with powers of entry for the purpose, and may take proceedings against those who wilfully violate or neglect the regulations.

S. 142 deals with the removal of infectious corpses (p. 527).

P.H.A., 1896.

S. 1.—The L.G.B., in any regulations made under ss. 130 and 134 of P.H.A., 1875, may provide for such regulations being enforced and executed by the officers of Customs, and the officers and men employed in the coastguard, as well as by other authorities and officers.

The L.G.B. may further provide for—(*a*) the signals to be hoisted by vessels having infectious cases on board; (*b*) the interrogatories to be answered by the masters, etc., of such ships; (*c*) the detention of vessels and persons on board them; (*d*) the duties of masters, etc. in such cases.

The penalty for obstructing the execution of this Act must not exceed £100.

The Act confers powers on the L.G.B. as to quarantine, and repeals the Quarantine Act, 1825.

I.D.N.A., 1889.

This Act applied to any U.S.A., R.S.A., or P.S.A., when adopted, but now extends to the whole country, and renders compulsory the notification of infectious disease.

I.D.N.A., 1899.

This Act repealed the adoption clauses of the 1889 Act, and made it compulsory.

The provisions of the I.D.N.A. are as follows:—

Notification is compulsory with regard to certain specified diseases occurring in any building used for human habitation, including ships, tents, vans, etc.; but excepting an infectious diseases hospital and ships belonging to His Majesty or to any foreign government.

The obligation of notification is dual, resting upon the public, as well as upon the medical profession; in the one case, upon the head of the family to which the sick person belongs, or in default, the nearest relatives of such person, or in default, those relatives present in the building or in attendance on the patient, or in default, every person in charge of or in attendance on the patient, or in default, the occupier of the building, *i.e.* the person having the charge, management, and control of the building, or the receiver of rent, or the master of the ship, or the person in charge of the ship; in the other case, upon every medical practitioner attending on or called in to visit the patient.

Notice is to be given to the M.O.H. as soon as the patient's friends become aware that he is suffering from any of the diseases to which the Act applies.

The medical practitioner must forthwith, on becoming aware that the patient is suffering from an infectious disease to which this Act applies, send to the M.O.H. of the district a certificate stating the name of the patient, the situation of the building, and the infectious disease from which he considers the patient to be suffering.

The penalty for neglecting the duty of notification is a fine of 40s., unless a person not primarily liable to notify can satisfy the court that there was reasonable cause to suppose that the notice had been duly given.

The L.G.B. prescribe the form of certificate, and its use is obligatory; and the L.A. must gratuitously supply forms of certificate to all medical practitioners residing or practising in their district on application for the same. The L.A. must pay the medical practitioner for each certificate a fee of two shillings and sixpence, if the case occur in his private practice, and of one shilling if the case occur in his practice as medical officer of any public body or institution.

If there be several M.O.H. in a district, the certificate is to be sent to the M.O.H. of the area in which the case is, or to the M.O.H. directed by the L.A. to receive such certificates.

The notifiable diseases are—smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlatina or scarlet fever, the fevers known as typhus, typhoid or enteric, relapsing, continued, and puerperal, and in any particular district, any infectious disease to which this Act has been applied by the L.A. of the district.

The L.A. has power to make permanent or temporary addition to this list of any infectious disorder by a resolution which requires the sanction of the L.G.B., and may not be revoked or altered without similar sanction. The certificates and notices sent to the M.O.H. under this Act must be in writing or print, or partly both, and may be delivered personally to the M.O.H., or be left at his office or residence, or may be sent by post to him at either place.

It was important to note that the Act contained no means whereby a L.A. might rescind its adoption of the Act. This is not now important, since the Act is no longer adoptive.

I.D.P.A., 1890 (Adoptive).

This is an Act applying, after adoption, to any extra-metropolitan U.S.A. or R.S.A. who may adopt it in whole or in part, or may rescind the adoption. It applies to the infectious diseases specified in the I.D.N.A, 1889, and to any other disease to which the L.A. apply it by resolution approved by the L.G.B. Its provisions refer to the inspection of dairies and powers to prohibit the supply of milk, the cleansing and disinfecting of premises and conveyances, the neglect of disinfection of premises, the disinfection of bedding, interments, compulsory detention in hospital, disinfection of rubbish, and the provision of temporary shelters.

If any person in the district is suffering from infectious disease, which the M.O.H. possesses evidence to show is attributable to milk supplied from any dairy within or without the district, the M.O.H. may obtain an order from a justice having jurisdiction in the place in which the dairy is situated, and may inspect the dairy. Further, if accompanied by a veterinary surgeon, the M.O.H. may inspect the animals therein, and may report to the L.A., who may make an order requiring the dairyman not to supply any milk therefrom within the district. The L.A. must give notice of such order to the L.G.B., the C.C., and any L.A. concerned, and the order shall be forthwith withdrawn if the L.A. or the M.O.H. is satisfied that the milk supply has been changed, or the cause of infection been removed. Penalties are provided for contravention or obstruction, and a dairyman is not liable for breach of contract due to his observance of such an order of the L.A.

The adoption of this Act repeals s. 120 of the P.H.A., 1875, and substitutes similar but modified regulations for cleansing and disinfecting premises and their contents. The L.A. may give written notice to the owner or occupier that the required cleansing and disinfection will be done by the L.A. at the cost of the said owner or occupier, unless within twenty-four hours he agree to do the same to the satisfaction of the M.O.H. and within a specified time. If he do not so agree, or, if having agreed, he fail to do the work within the specified period, the L.A. must themselves do what is necessary, and may recover the cost in a summary manner.

The L.A. may cleanse and disinfect at their own cost, with the consent of the owner or occupier, in those cases where he is unable to do so effectually.

Every person who shall cease to occupy any house, room, or part of a house in which any person has within six weeks been suffering from any infectious disease, must—(1) disinfect such house, etc., and contents to the satisfaction of a medical practitioner as certified by him; (2) notify the owner of the previous existence of such disease; and (3) not knowingly make a false statement to the owner or applicant for the hire of such house, etc. The L.A. must give notice of this provision to the occupier of any house in which the L.A. are aware there is a person suffering from infectious disease. It is unlawful for any person to hire or use any public conveyance, other than a hearse, for the conveyance of the body of a person dead of infectious disease, without first warning the owner or driver, who must provide for its disinfection.

The L.A. or M.O.H. may require the disinfection of any infected bedding, clothing, or other articles, and the L.A. may remove, disinfect, and return such articles free of charge, and must compensate the owner for unnecessary damage.

No person may, without the written sanction of the M.O.H., or a registered medical practitioner, retain unburied, elsewhere than in a public mortuary or in a room not used at the time as a dwelling-place, sleeping-place, or workroom, for more than forty-eight hours, the body of any person who has died of any infectious disease. The body of any person dying of infectious disease in hospital may only be removed for the purpose of being forthwith buried, or to a mortuary, provided the M.O.H., or a medical practitioner, certifies that this is desirable to prevent infection. If the body of any person who has died of infectious disease remain unburied for more than forty-eight hours without the sanction mentioned above, and in an unsuitable place, or if the dead body of any person is retained in any house or building so as to endanger the health of the inmates of such, or of any adjoining building, any justice may, on the application of the M.O.H., order the L.A. to remove the corpse to a mortuary, and may direct its burial within a specified time or immediately. The relieving officer must bury the body, unless the friends of the deceased do so within the specified time.

Any justice may, by order, detain in hospital at the cost of the L.A. any person suffering from infectious disease, who is either in an infectious diseases hospital, or who, upon leaving, would not have accommodation in which proper precautions could be taken to prevent the spread of infection. The order may specify a period which may be extended as often as is necessary. Infectious rubbish must not be thrown into an ashpit or other receptacle without previous disinfection, and the L.A. must serve notice of this proviso upon the occupier of any house in which they are aware that infectious disease exists. The L.A. must provide free temporary shelters for the members of any family compelled to leave their house so that disinfection of the premises may be performed by the L.A.

Offences against this Act are visited by fine, and, if necessary, a daily penalty; and powers of entry are conferred upon the L.A. for the cleansing and disinfection of premises.

I.H.A., 1893.

This is an Act to enable County Councils to promote the establishment of infectious diseases hospitals. It does not extend to London, Ireland, or Scotland, or to any county borough, but with the consent of the Borough Council may extend to boroughs having more than 10,000 inhabitants. The L.G.B. may apply it to any borough with less than this number of inhabitants.

For the establishment of a hospital the procedure is—(1) An application to the C.C. by (*a*) any L.A. having jurisdiction in the county, or (*b*) not less than twenty-five ratepayers in any contributory place, followed by an inquiry by the C.C. into the facts if a primâ facie case has been established to their satisfaction; or (2) a report of the county M.O.H. directed by the C.C. itself. The district for which the hospital is to be provided is to be called the "Hospital District," and must consist of one or more local areas, *i.e.* U.S.D., R.S.D., or contributory place. No local area can be included in a hospital district without the consent of its L.A. if it already has, in the judgment of the C.C., adequate accommodation; nor must a hospital district be formed for one local area only, or for one or more local areas within the same R.S.D., without the consent of the L.A., unless the C.C. are satisfied that the L.A. are unable or unwilling to make suitable provision for the purpose. A L.A. may appeal to the L.G.B. against the formation of the hospital district. A hospital committee is formed for the district, and has power to borrow money, to hold lands, to erect and maintain a hospital, and to provide temporary shelters, such as tents, huts, and cottages for isolation purposes for non-populous places. The hospital committee may charge patients for exceptional accommodation, may train nurses, and may charge for the attendance of nurses on cases outside the hospital. An ambulance must be provided, and the hospital should not be far from a telegraph office. Pauper patients are to be paid for by the guardians of the union from which they are sent, and non-pauper patients by the L.A. of the local area from which they are sent. The term "infectious disease" includes those diseases specified in the I.D.N.A., and the C.C. may extend the term so as to include other diseases. The L.As. in the hospital district contribute in proportions fixed by the C.C. to the expenses of the structure and establishment.

MERCHANT SHIPPING ACT, 1894 (see p. 537).

C.D.(A.)A., 1878 and 1886.

Under this Act the L.G.B. have power to make orders, such as the D.C.M.O. (p. 546), and these orders throw the duty of controlling the milk supply upon the L.A. The spread of infectious disease may be combated by means of these powers, for the L.A. are authorised by the D.C.M.O. to make regulations having the force of by-laws.

F.&W.A., 1901 (p. 574, c.).

MEMORANDUM OF THE L.G.B., 1890 (see p. 286).

EDUCATION CODE, Art. 98 (see p. 286).

REGULATIONS OF THE L.G.B. AS TO CHOLERA, YELLOW FEVER, AND PLAGUE. See Port Sanitary Authorities, p. 537.

ORDERS OF THE L.G.B. (see s. 314, P.H.A., p. 521).

LONDON.

Acts Concerned.

P.H.(L.)A., 1891; C.D.(A.)A., 1878 and 1886; Merchant Shipping Act, 1894; F.&W.A., 1901. In addition, Memorandum of the L.G.B.; Education Code, art. 98; Regulations of the L.G.B.; Orders of the L.G.B.

P.H.(L.)A., 1891.

This Act includes provisions of the I.D.N.A. and I.D.P.A. Notification of infectious disease is compulsory in London, and the fees paid for it are the same as under the I.D.N.A. The certificate must include the age and sex of the patient, as well as the other particulars required by the I.D.N.A., and must state whether the case occurred in private practice, or in practice as medical officer of any public body or institution. If the case is in hospital, the certificate must also state the date of admission, and the place from which the patient came. The M.O.H. must send a copy of every notification certificate to the Metropolitan Asylums Board, and to the head teacher of the school attended by the patient if a child, or by any child who is an inmate of the same house as the patient. The Metropolitan Asylums Board furnish the C.C. and every M.O.H. with a weekly return showing all notifications.

The scheduled diseases are the same as in the I.D.N.A., and the municipal borough councils have power to add other diseases to the list for their respective districts. Further, the L.C.C. may likewise add other diseases to the list for the whole county of London.

The "dangerous infectious diseases" mentioned in s. 126 of the P.H.A., 1875, are defined in the London Act as those which are compulsorily notifiable: thus some of the safeguards against diseases not included in the list are withdrawn.

No public conveyance may be used in London to transport cases of dangerous infectious disease, but ambulances are provided at a charge by the Metropolitan Asylums Board.

The S.A. must provide means for disinfection, and can make no charge for their use. A person who is aware that he has any dangerous infectious disease must not milk animals, pick fruit, or engage in any business in such a way as to be likely to spread the disease.

The Metropolitan Asylums Board require the consent of the L.G.B. before acquiring a site for the erection of an infectious diseases hospital. The L.C.C. is one of the L.As. which may be required to carry out regulations made by the L.G.B. under s. 134 of the P.H.A., 1875, and may be empowered to act in default of any L.A. The general scope of the provisions of the P.H.(L.)A., 1891, in regard to other matters in connection with infectious disease, is similar to that of the P.H.A., 1875.

The other effective Acts are the same as in England and Wales.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878; I.D.N.A., 1889; I.D.P.A., 1890 (adoptive); Merchant Shipping Act, 1894; F.&W.A., 1901. In addition, Memorandum of the L.G.B.; Regulations of the L.G.B.; Orders of the L.G.B.

These Acts have been already explained, since their provisions are practically the same in Ireland as in England, the P.H.A., 1878, being substituted for the P.H.A., 1875.

The I.D.N.(Extension)A. of 1899 does not apply to Ireland.

Mortuaries.

ENGLAND AND WALES.

Act Concerned.

P.H.A., 1875. In addition, Model By-laws; Suggestions by the L.G.B.

P.H.A., 1875.

S. 141.—Any L.A. may, and if required by the L.G.B., must, provide a properly equipped mortuary, and may make by-laws with regard to it. The L.A. may provide for the interment of any body received into the mortuary, and burial charges are fixed by the by-laws.

S. 142.—The body of any dead person which is in such a state as to endanger the health of the inmates of the house or room in which it is kept, may, by order of a justice, on a certificate signed by a medical practitioner, be removed to a mortuary. The same provisions apply to the body of any person who has died of any infectious disease if it be retained in a room in which persons live or sleep. The justice may direct any such body to be buried within a specified time, and if the friends of the deceased do not comply, it is the duty of the relieving officer to bury such a body, any expenses being recovered from the person legally liable.

S. 143.—Any L.A. may provide and maintain a proper place (otherwise than at a workhouse or at a mortuary) for the carrying out of post-mortem examinations which are officially ordered.

MODEL BY-LAWS AND SUGGESTIONS OF THE L.G.B.

A body deposited in the mortuary must be removed therefrom for interment within . . . days after death; but if the deceased has died of an infectious disease, the body must be removed for interment within . . . days after death.

Construction and Management of Mortuaries.

The buildings should be isolated and unobtrusive, but substantial structures of brick and stone. Every chamber for the reception of corpses should be on the ground floor. In addition to such chamber, there should be a waiting-room, a caretaker's house, and a shed or outhouse. Every mortuary chamber should be lofty, and there should be a ceiling, or a double roof, with an intervening space of 8 in. for the sake of coolness. The area should be sufficient to allow freedom of movement between the slabs. The windows should be on the north side if practicable ; if otherwise, they should have external louvre blinds. Louvres or air-gratings under the eaves will be the best means of ventilation. The pavement must be even and close, and a cement floor is preferable. The slabs should be of slate, and $2\frac{1}{2}$ to 3 ft. from the floor. Water should be laid on within the chamber. The walls and ceilings should be whitewashed, and the outside of the roof also whitened. There should be at least two chambers, one of which may be reserved for bodies of persons who have died of infectious disease. There should be a resident caretaker, and bodies should be received at any hour of the day or night.

LONDON.

Act Concerned.

P.H.(L.)A., 1891. In addition, Model By-laws, etc., of L.G.B.

Every S.A. must provide a mortuary, and may provide a place for post-mortem examinations. The latter provision is compulsory if required by the C.C. The C.C. has powers to provide other mortuaries for the reception of bodies awaiting identification, and must provide accommodation for inquests.

IRELAND.

Act Concerned.

P.H.(I.)A., 1878. In addition, Model By-laws, etc., of L.G.B.

This is the same as the P.H.A., 1875.

New Streets and Buildings.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875 ; P.H.A.A.A., 1890, Part III. (adoptive) ; T.I.C.A., 1847. In addition, Model By-laws.

P.H.A., 1875.

S. 149.—All public streets in urban districts are vested in the U.A., who must cause them to be levelled, paved, repaired, and altered as occasion may arise.

S. 150.—The U.A. may require the owners of property abutting on any private street, or part of a street, to level, pave, sewer, light, or make good such street, and in default, the U.A. may do the work, and recover expenses from the owners proportionate to their respective frontages.

S. 157.—An U.A. may make by-laws with respect to—

(1) The level, width, and construction of new streets, and the provisions for the sewerage thereof. (2) The structure of walls, foundations, roofs, and chimneys of new buildings, for securing stability, for the prevention of fires, and for purposes of health. (3) The sufficiency of the space about buildings to secure a free circulation of air, and with respect to the ventilation of buildings. (4) The drainage of buildings, to water-closets, earth-closets, privies, ashpits, and cesspools in connection with buildings, and to the closing of buildings or parts of buildings unfit for human habitation, and to prohibition of their use for such habitation.

S. 159.—For the purposes of this Act, the re-erection of any building pulled down to or below the ground-floor, or the conversion into a dwelling-house of any building not originally constructed for human habitation, or the conversion into more than one dwelling-house of a building originally constructed as one dwelling-house only, is considered the erection of a new dwelling.

S. 160.—This section incorporates certain clauses of the T.I.C.A., which provides—(*a*) An U.S.A. may compel the owner of any building near a street to provide efficient eaves, gutters, and rain pipes. (*b*) The surveyor of an U.S.A. must fence any building or wall so ruinous as to be dangerous to passers-by or neighbouring residents, and must order the owner forthwith to demolish or render secure such building or wall. In default, the surveyor may, by order of a justice, do the work and recover the cost. (*c*) The U.A. may supervise the planning of new streets, the improvement of old ones, and general laying out of the town.

S. 276.—The above sections apply to U.As., but R.As. may under this section obtain similar powers by application to the L.G.B.

P.H.A.A.A., 1890, Part III. (Adoptive).

S. 23.—This extends the powers of an U.A. under s. 157, P.H.A., as to the making of by-laws, and specifies the following matters:—(*a*) Sufficient flush-water for closets; (*b*) construction of floors, hearths, and staircases, and the height of rooms intended for habitation; (*c*) paving of yards and open spaces in connection with houses; (*d*) secondary means of access to houses for removal of refuse. These by-laws, and those mentioned in s. 157, may apply to old as well as new buildings, and power is given to R.As., as well as U.As., to make by-laws on certain of the subjects connected with buildings. Any S.A. may make accessory by-laws to prevent buildings, erected in accordance with by-laws, from being altered in such a way that, if at first so constructed, they would have contravened the by-laws.

S. 24.—No room, of which any portion extends over any privy (not being a water-closet or earth-closet), cesspool, midden, or ashpit, must be occupied or granted for occupation as a dwelling-place, sleeping-place, workroom, or place of business.

S. 25.—No new building may be erected on any ground filled up with, or receiving deposit of, any matter impregnated with fæcal, animal, or vegetable matter, unless such matter has been properly removed, or has been rendered or become innocuous.

S. 33.—Buildings described in deposited plans otherwise than as dwelling-houses, must not be used as such, except by a caretaker and his family. The owner may use such a building as a dwelling-house if there is adequate open space belonging thereto, and if such structural alterations are introduced as will, in the opinion of the L.A., render it fit for such use.

S. 34 refers to the protection of the public by hoardings, etc., erected at new buildings; s. 35 to the repair of cellars under streets; and s. 36 to the means of ingress and egress from places of public resort.

MODEL BY-LAWS.

The provisions of these by-laws dealing with house drainage and sanitary conveniences were considered on pp. 498, 493. Those here mentioned deal with streets, sites, construction, ventilation, etc.

(*a*) *Streets.*—No new street must be less than 36 ft. wide if it exceeds 100 ft. in length, or is intended to be a carriage road; nor less than 24 ft. in any case. One end, at least, must be quite open.

(*b*) *Sites.*—No buildings must be erected upon soil polluted with animal or vegetable matter. Sites in low and damp situations, near rivers, or in excavations, must be elevated artificially. The site of a new house must be entirely asphalted or covered with 6 in. of concrete.

(*c*) *Walls of all new buildings* must be constructed of good bricks, stone, or other hard and incombustible materials, properly bonded, and solidly put together with good mortar compounded of good lime and clean, sharp sand or other suitable material, or with good cement, or with good cement mixed with clean, sharp sand. Every wall must have a proper damp course of durable and impervious material beneath the level of the lowest timbers, and at least 6 in. above the ground. If the ground is to be in contact with a wall above the level of the floor of the lowest storey, that wall must be made double, with a cavity of 2½ in. wide, extending from the base of the wall to 6 in. above the surface of the adjoining ground; and damp courses must be inserted, both at the base of the wall and at the level of the top of the cavity. Walls of new houses must be at least 9 in. thick, increasing according to a prescribed scale when the height is greater than 25 ft., or the length greater than 30 ft. Party-walls must be carried up at least 15 in. above the roof, the distance to be measured at right angles to the slope of the roof.

(*d*) *Roofs* must be made of incombustible materials, and provided with gutters leading to rain pipes.

(*e*) *Open space.*—A new house must have along its whole frontage an open space measuring at least 24 ft. to the boundary of any land or premises immediately opposite, or to the opposite side of the street. In the rear there must be an open space exclusively belonging to the house, at least 150 square ft. in area, and free from any erection above the ground-level, except a closet and an ashpit; the open space must extend along the entire width of the house, and must measure in no case less than 10 ft. from every part of the back wall of the house; if the house is 15 ft. high, the distance must be 15 ft.; if 25 ft., then 20 ft.; and if 35 ft. or more, then 25 ft. at least.

(*f*) *Ventilation beneath floors.*—If the floor of the lowest storey is boarded, there must be a clear space of at least 3 in. between the boards and the impervious covering of the site, and the space must be ventilated.

(*g*) *Windows* opening directly into the external air must be provided in every habitable room. The window area must be at least one-tenth of the floor area; at least half of each window must be made to open, and it must open at the top.

(*h*) *Ventilation.*—Every habitable room must either have a fireplace and chimney, or a special ventilating aperture or air-shaft, with an unobstructed sectional area of at least 100 square in. Every new building must be provided with adequate means of ventilation, and to secure this, so far as dwelling-rooms in general are concerned, the minimum height should be 9 ft. in every part, except in attics used as bedrooms, when a minimum height of 5 ft. is permitted, if in two-thirds of the area the height is not less than 9 ft.

(*i*) *Closure of premises unfit for occupation.*—The S.A. may, under certificate from the M.O.H. or surveyor, declare any building, or part of a building, erected after . . . unfit for habitation. Opportunity must be given to the owner to show cause why such order should not be made.

(*j*) *Plans and sections* must be submitted, showing in detail the construction of all proposed new streets or buildings. (The P.H.A., s. 158, requires that the S.A. shall signify their approval or disapproval of the plans within a month after receiving them.)

(*k*) *Inspection.*—Notice must be given to the surveyor regarding the dates upon which work is to be commenced, and upon which any sewer, drain, or foundation is to be covered up; notice must also be given of the completion of the work. Free access for inspection must be afforded to him at all times during the progress of the work.

(*l*) *Demolition of illicit works.*—If any work, to which the by-laws apply, is done in contravention of such by-laws, the S.A. are empowered to remove, alter, or pull down such work.

LONDON.

Acts Concerned.

P.H.(L.)A., 1891; London Building Act, 1894; Metropolitan Building Acts, 1855, 1882; City of London Sewers Acts, 1848, 1851; Metropolitan Paving and Streets Regulation Act, Metropolis Management Act, 1855; Metropolis Management Amendment Acts, 1862, 1890; Metropolis Management Building Act Amendment Act, 1878; Metropolis Board of Works Act, 1882; London Council (General Powers) Act, 1890; F.&W.A., 1891. In addition, Model By-laws.

The supervision of these matters in London rests in the City with the Commissioners of Sewers, and elsewhere with the L.C.C. The chief Act is the London Building Act, which applies, as a whole, to the Metropolitan area, but from certain sections of which the City of London is exempt. The Act is largely concerned with the general planning of streets and buildings, the laying out and erection of the same with a view to the prevention of overcrowding of buildings, and the provision of sufficiently broad thoroughfares. Special attention is paid to securing sufficient open spaces about buildings, and to regulating the height to which buildings on any site may attain, so that the occlusion of light and interference with free ventilation may be prevented. Means of escape in case of fire must be provided in every building above a certain height, and buildings must not be nearer than 50 ft. to the business premises of dangerous and noxious trades. The site of any building must be at a sufficient elevation to allow of drainage of the building into a sewer, and to obviate risk of flooding during rain or high tides. Otherwise the provisions of the Act closely resemble those of the Model By-laws, but have a somewhat wider scope. Certain points, *e.g.* the drainage of houses, the construction of cellars and vaults under streets, and the erection of hoardings during building, are dealt with in other Acts, and the P.H.(London)A. regulates the sanitary requirements of houses, the construction of underground rooms, and of the premises used for offensive trades.

IRELAND.

Acts Concerned.

P.H.(I.)A. 1878; P.H.A.A.A., 1890; Towns Improvement (Ireland) Act, 1854. In addition, Model By-laws.

The P.H.(I.)A. is practically the same as the P.H.A., 1875, but under it R.As. can make by-laws just as U.As. can do. The P.H.A.A.A. applies to Ireland, and is the same as in England, though the extension of powers to R.As. does not require to be utilised. The T.I.A. confers the control of the planning and erection of places of public entertainment on the Town Commissioners.

Public Pleasure Grounds, etc.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875; P.H.A.A.A., 1890; L.G.A., 1894; Open Spaces Act, 1887; Commons Act, 1876. In addition, Model By-laws.

P.H.A., 1875.

S. 164.—Any U.A. may provide by purchase or lease, or may contribute to, lands for use as public walks or pleasure grounds; they may lay out, plant, and improve the same, and may make by-laws regulating the use thereof.

P.H.A.A.A., 1890.

S. 44.—The U.A. may close public pleasure grounds certain days in the year, but not on a Sunday or public holiday, and may on those days charge for admission.

S. 45.—This extends the powers granted to U.As. under s. 164, P.H.A.

L.G.A., 1894.

Confers on P.Cs. the above powers of U.As. under s. 164, P.H.A.

OPEN SPACES ACT, 1887.

Gave S.As. the power to acquire, maintain, and regulate open spaces for public use, and to thus utilise disused burial grounds.

COMMONS ACT, 1876.

U.As. of places having more than 5000 inhabitants are endowed with powers with regard to the preservation of commons.

LONDON.

Acts Concerned.

Metropolis Open Spaces Acts, 1877, 1881, and 1887; Gardens in Towns Protection Act, 1863; Metropolis Management Act, 1855; Metropolitan Commons Act, 1878; Corporation of London (Open Spaces) Act, 1878. In addition, Model By-laws.

The general powers of the authorities in London are similar to those of England and Wales as to open spaces. Inhabitants of houses in squares, crescents, etc., may be rated for the upkeep of gardens adjacent.

IRELAND.

Acts Concerned.

Open Spaces Acts, 1877, 1887; Metropolitan Open Spaces Act, 1881; P.H.A.A.A., 1890; Towns Improvement (Ireland) Act, 1854; Public Parks (Ireland) Act, 1869. In addition, Model By-laws.

The effect of the various clauses in these Acts is to confer on U.S.As. much the same powers as those possessed by English authorities, though the P.H.A., 1878, has no clause corresponding to s. 164, P.H.A., 1875.

Slaughter-Houses.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875; (T.I.C.A., 1847), incorporated in foregoing; P.H.A.A.A., 1890. In addition, Model By-laws; Memorandum of L.G.B., 1877.

Definition (p. 486).

P.H.A., 1875.

S. 169.—An U.A. may provide slaughter-houses, and if so, must make by-laws as to their management and the charges for their use. The clauses of the T.I.C.A. are by this section incorporated in this Act. The U.A. may licence slaughter-houses and knackers' yards, and without such licence no premises may be used for the purpose which were not so used prior to the passing of the Act. The U.S.A. must keep a register of *every* place used as a slaughter-house or knacker's yard, and of the name of the owner or occupier. An U.S.A. must make by-laws in regard to slaughter-houses and knackers' yards, *e.g.*, as to water supply, cleanliness, removal of refuse, inspection, and prevention of cruelty. If any person is convicted of killing or dressing any cattle contrary to the provisions of the Act, or of the non-observance of any of the by-laws or regulations, the justices may suspend his licence for any period not exceeding two months, and at the second offence may revoke his licence.

S. 170.—The owner or occupier of any licensed or registered slaughter-house must affix conspicuously on the premises a legible notice bearing the words "licensed slaughter-house" or "registered slaughter-house," as the case may be.

P.H.A.A.A., Part III. (Adoptive).

These sections cannot be adopted by R.S.As. unless invested with urban powers.

S. 29.—Licences granted after the adoption of this Act shall remain in force only for such period, not being less than a year, as the S.A. shall specify in such licences.

S. 30.—Upon any change of occupation of any registered or licensed slaughter-house, the occupier or joint-occupier must notify the same to the I.N., under a penalty for failure so to do, and information as to this enactment must be endorsed on all new licences.

S. 31.—If the occupier of a licensed slaughter-house is convicted under s. 116, P.H.A., 1875 (p. 519), his licence may be revoked by the justice.

MODEL BY-LAWS.

(*A*) Licences.

Application for licence of existing premises, or erection of new slaughter-houses, must be made upon a specified form, and must include full particulars as to the position, form, area, cubic space, etc., of the buildings and appendages; materials and construction of walls and floors; means of water supply, drainage, lighting, and ventilation; means of access for cattle; number, position, and size of stalls or lairs, and number of animals to be accommodated therein, distinguishing oxen, calves, sheep, and swine. The boundaries must also be shown, and, in the case of old premises, particulars as to the ownership and the applicant's tenure must be given.

(*B*) Registration.

If the S.A. approve the application, a licence shall be issued to the applicant, and must be registered by him at the office of the S.A.

(*C*) Inspection.

Free access to every slaughter-house for the purpose of inspection must be afforded at all reasonable times to the M.O.H., I.N., surveyor, and committees appointed by the S.A.

(*D*) Watering of Animals.

Water must be supplied to every animal kept in a lair prior to slaughter.

(*E*) Mode of Slaughter.

Cattle must be secured by the head so as to be felled with as little pain as practicable.

(*F*) Drainage, Water Supply, and Ventilation.

These must be kept in efficient order.

(*G*) Cleanliness.

The walls and floors must be kept in good order and repair, and must be thoroughly cleansed within three hours after any slaughtering; the walls and ceiling must be limewashed four times yearly, that is to say, within the first ten days of March, June, September, and December respectively.

(*H*) Animals not to be kept.

No dog may be kept in a slaughter-house; nor other animal, unless intended for slaughter upon the premises, and then only in proper lairs, and not longer than may be necessary for preparing it for slaughter by fasting or otherwise.

(*I*) Removal of Refuse.

Suitable vessels made of non-absorbent materials, and provided with close-fitting covers, must be provided for the reception of blood, manure, garbage, and other refuse; all such matters must be placed in these vessels immediately after the slaughtering; the refuse must be removed within twenty-four hours, and the vessels forthwith cleansed. All skins, fat, and offal must be removed within twenty-four hours.

MEMORANDUM OF L.G.B.

"1. The premises should not be within 100 ft. of any dwelling-house; and the site should be such as to admit of free ventilation by direct communication with the external air on two sides at least of the slaughter-house.

"2. Lairs for cattle in connection with the slaughter-house should not be within 100 ft. of a dwelling-house.

"3. The slaughter-house should not in any part be below the surface of the ground.

"4. The approach to the slaughter-house should not be on an incline of more than one in four, and should not be through any dwelling-house or shop.

"5. No room or loft should be constructed over the slaughter-house.

"6. The slaughter-house should be provided with an adequate tank or other proper receptacle for water, so placed that the bottom shall not be less than 6 ft. above the level of the floor of the slaughter-house.

"7. The slaughter-house shall be provided with means of thorough ventilation.

"8. The slaughter-house should be well paved with asphalt or concrete, and laid with proper slope and channel towards a gully, which should be properly trapped and covered with a grating, the bars of which should not be more than three-eighths of an inch apart. Provision for the effectual drainage of the slaughter-house should also be made.

"9. The surface of the walls in the interior of the slaughter-house should be covered with hard, smooth, impervious material to a sufficient height.

"10. No water-closet, privy, or cesspool should be constructed within the slaughter-house. There should be no direct communication between the slaughter-house and any stable, water-closet, privy, or cesspool.

"11. Every lair for cattle in connection with the slaughter-house should be properly paved, drained, and ventilated.

"12. No habitable room should be constructed over any lair."

LONDON.

Acts Concerned.

P.H.(L.)A., 1891; Metropolitan Market Acts, 1851, 1857.

In addition, Model By-laws; Memorandum of L.G.B., 1877.

The licensing authority in London is the L.C.C., and in the City the Commissioners of Sewers. The authority may make by-laws as to the mode of application for licence, and as to the premises and the conduct of the trade. No person may use premises for such business without a licence. The Metropolitan Cattle Market is under the Special Acts. The general provisions are similar to those mentioned above.

IRELAND.

Acts Concerned.

P.H.(I.)A., 1878; (T.I.C.A., 1847), incorporated; P.H.A.A.A., 1890, Part III. (adoptive). In addition, Model By-laws and Memorandum of L.G.B.

There is little difference in the law in Ireland from that described under England and Wales.

Port Sanitary Authorities.

ENGLAND AND WALES.

Acts Concerned.

P.H.A., 1875; P.H.(Ships, etc.)A., 1885; P.H.(Ports)A., 1896; P.H.A., 1896; Merchant Shipping Act, 1894. In addition, Orders of L.G.B.; Regulations of L.G.B.

P.H.A., 1875.

S. 287.—The L.G.B. may, by order, constitute any L.A. whose district abuts upon any port in England or Wales, or the waters of such port, the S.A. for the whole or any part of such port. The L.G.B. may also combine riparian authorities for the purpose, or may constitute one P.S.A. for any two or more ports. The authority may be constituted permanently or temporarily. The order may assign to the P.S.A. any powers, rights, duties, capacities, liabilities, and obligations of a U.S.A. so far as applicable to a P.S.A.

S. 288.—The order gives the P.S.A. jurisdiction over all waters within the limits of such port.

S. 289.—The P.S.A. may delegate their powers to any riparian authority.

The order may specify certain portions of the P.H.A., and declare the duties and powers of P.S.A. to be those conferred by such portions of the Act. Those usually so specified are ss. 91 to 111 (nuisances); ss. 120 to 133 (infectious diseases and hospitals); ss. 134 to 138 (prevention of epidemic disease); ss. 141 to 142 (mortuaries); ss. 182 to 186 and 188 (by-laws); s. 189 (appointments of M.O.H. and I.N.), and other sections.

P.H.(SHIPS, ETC.)A., 1885.

It amends the above Act, s. 2 applying the provisions of the P.H.A., 1875, as to infectious diseases and hospitals to ships.

S. 3 enacts that an Order of the L.G.B. constituting a P.S.A. does not require confirmation by Parliament.

P.H.(PORTS)A., 1896.

The L.G.B. may, by order, assign to the P.S.A. any powers, duties, or obligations under the I.D.P.A., 1890, with the necessary modifications.

P.H.A., 1896.

This Act repeals the Quarantine Act of 1825, and confers power on the L.G.B. to provide for the execution of their regulations under ss. 130 and 134, P.H.A., 1875, by Customs and coastguard officers and men (p. 521).

MERCHANT SHIPPING ACT, 1894.

The Crown may, by Order in Council, make regulations—(*a*) for preserving order, promoting health, and securing cleanliness and ventilation on board emigrant ships proceeding from the British Isles to any port in a British possession; (*b*) for prohibiting emigration from any port at any time when choleraic or any epidemic disease is generally prevalent in the British Islands or any part thereof.

ORDERS OF L.G.B.

The Order prescribing the duties of a port M.O.H. has already been mentioned (p. 480). The L.G.B., when foreign ports are infected, issue and afterwards rescind orders containing regulations regarding the importation of rags, bedding, clothing, etc., and prescribing the steps to be taken for their disinfection or destruction.

REGULATIONS OF L.G.B.

Those at present in force were framed under the P.H.A., 1875, s. 130; the P.H.A., 1896; and the P.H.(Ports)A., 1896, and apply to cholera, yellow fever, and plague, the term "cholera" including choleraic diarrhœa. These regulations apply to ships "coming foreign," and are for the purpose of preventing the importation of these diseases. A ship is deemed to be "infected" in which there is or has been during the voyage, or during the stay of such ship in the port of departure, or in a port in the course of such voyage, any case of cholera, yellow fever, or plague. It is the duty of a Customs officer on the arrival of any ship "coming foreign" to ascertain whether such ship is "infected," and if he find or suspect such to be the case, he must detain such ship, and order the master forthwith to moor or anchor the same in a specified place, and the master must obey such order. During detention no person shall leave the ship, and the officer of Customs must notify the detention to the S.A. Every P.S.A., or other S.A., within whose district persons are likely to be landed from any ship "coming foreign," must appoint a place for mooring infected ships, and must provide for the reception of patients suffering from these diseases. The S.A., on receipt of notice from the Customs officer, shall cause the ship to be visited and examined by their M.O.H., who is bound to visit it within twelve hours. The M.O.H., if he suspect that any ship within the district of the S.A. is infected, whether examined by the officer of Customs or not, must visit and examine such ship, and he may do so if he suspect any ship to have come from an infected place, and he may cause such ship to be moored in the specified place. The M.O.H. must certify both the master and the S.A. if he consider that the ship is infected, and must inform the L.G.B. The M.O.H. must then examine every person on board the infected ship, and no person may leave the ship till the examination is completed. The M.O.H. must certify as to any person whom he finds to be suffering from any of these diseases, and such person must be removed to hospital if his condition admit of it, and must not leave such hospital until the M.O.H. certifies that he is free from disease. If the sick person cannot be removed, the ship remains subject to the control of the M.O.H., without whose written consent he must not leave the ship or be removed from it. Any person certified by the M.O.H. to be suffering from any illness which the M.O.H. suspects may prove to be cholera, yellow fever, or plague, may either be detained on board the ship for any period not exceeding two days, or be taken to hospital or other suitable place, and detained there for a like period, in order that it may be ascertained whether the illness is or is not of the kind suspected. No person on board an infected ship may land unless he satisfy the M.O.H. as to his name, intended place of destination, and intended address at such place. These details are furnished by the M.O.H. to the clerk of the S.A., who transmits them to the L.A. of the district of destination. Any alteration of destination or address confers on the traveller the obligation of notifying his arrival to the M.O.H. or L.A. of the district at which he arrives, within forty-eight hours after landing. The M.O.H. must take all necessary precautions for preventing the spread of infection from an infected ship, and the master must carry out the directions of the M.O.H. In case of any death from these diseases taking place during the ship's detention, the master must, under the direction of the S.A. or M.O.H., either cause the dead body to be taken out to sea and there buried, properly weighted, or deliver it to the S.A. for proper disposal.

The master must disinfect or destroy all infected articles—fomites—and must disinfect the ship under the directions of the M.O.H. or S.A.

The master of an infected ship must cause to be hoisted at the masthead a large flag of yellow and black when within 3 miles of the coast of any part of England and Wales. An infected ship, or one from an infected port, may be emptied of bilge-water and water-ballast before entering dock if the M.O.H. considers this course desirable, or the M.O.H. may cause the water-ballast tanks to be sealed if emptying them would endanger the ship. The M.O.H. may order all casks or tanks containing drinking-water to be emptied and cleansed, provided that the S.A. furnishes a fresh and proper supply. When a vessel is not infected, but carries passengers in a filthy or otherwise unwholesome condition, the M.O.H. may certify to the master that, with the object of preventing the introduction of cholera, yellow fever, or plague, no persons should be allowed to land until they have satisfied the M.O.H. as to their names and places of destination, and addresses at such places. The same measures must then be carried out as mentioned above in the case of an infected ship.

N.B.—Letter mails are exempt from detention, disinfection, destruction, or any action which would delay delivery.

In view of the recent widespread prevalence of plague, the Society of M.O.H. has suggested to the L.G.B. revision of these Orders and Regulations, and on the following grounds :—

1. That there is no provision for the prevention of the introduction of plague by means of infected animals, such as rats.

2. That a ship, on which only the rats are, or have been, suffering from plague, is probably not an "infected" ship within the meaning of the regulations, and the P.S.A. has probably no power to enforce either the destruction of rats, the disinfection of the ship, or the taking of names and addresses of

persons employed on board. The regulations appear to apply only to a suspected ship *on arrival*, and not to include workmen employed in unloading. The remedy suggested is to extend the definition of "infected" vessel to cover cases of rat infection, and to extend the powers to any period *after arrival*.

3. There is no power to order destruction of all rats on vessels about to go to infected or suspected ports, and to order precautions to be taken during loading in such ports, for example, rat guards on cables, tarring of cables for 5 ft. from the quay wall, mooring at a distance from the quay wall, and raising of gangways at night.

4. That two days' detention of suspects is not long enough, and that no provision exists for the prolonged detention of cases of glandular enlargement in a ship not obviously infected.

5. It is not clear if vessels from infected home ports come under the regulations.

6. A night-signal is not provided for.

LONDON.

The Corporation of London are the P.S.A., and the same Acts, etc., apply with the substitution of the P.H.(London)A., 1891, for the P.H.A., 1875.

SCOTLAND.

As in England and Wales, and in place of the P.H.A., 1875, the P.H.(Scotland)A., 1897 (see p. 608).

IRELAND.

There are no P.S.As., but under the P.H.(Ireland)A., 1878, the L.G.B. for Ireland has issued Regulations and Orders similar to those in force in England.

. . . .

The important subjects dealt with in the P.H.A., 1875, having been considered seriatim, we now pass to the laws concerning other sanitary matters not included in the P.H.A. A few minor provisions of the latter, such as s. 314, dealing with movable dwellings, still remain to be mentioned, and will be found under the subjects to which they refer.

Horse-flesh.

Acts Concerned.

SALE OF HORSE-FLESH, ETC., REGULATION ACT, 1889.

Application.—Great Britain and Ireland.

Definition (p. 485).

Provisions.—(1) The flesh of horses, asses, or mules must not be sold for human food, except in a shop or stall over or upon which is placed conspicuously, in legible characters 4 in. long, an announcement that horse-flesh is sold there. (2) Horse-flesh must not be supplied for human food to a purchaser asking for other meat or for a compound not usually made of horse-flesh. (3) The M.O.H., or S.I., or any other officer of the S.A., may examine and seize any meat believed to be horse-flesh exposed for sale in any other shop.

Adulteration of Food.

Acts Concerned.

S.F.D.A., 1875, 1899; S.F.D.A.A.A., 1879; L.G.A., 1888.

Application.—Great Britain and Ireland.

Definitions.—Under the S.F.D.A., 1875, "*food*" is defined as including every article used by man for food or drink, except water and drugs, and "*drug*" as including medicine for external as well as internal use.

Under the S.F.D.A., 1899, "*food*" is defined as every article used for food or drink by man other than drugs or water, and any article which ordinarily enters into, or is used in the composition or preparation of, human food, including flavouring matters and condiments.

S.F.D.A., 1875.

Provisions.—No person shall mix, colour, stain, or powder, or order or permit any other person to mix, colour, stain, or powder any article of food intended for sale with any ingredient or material so as to render it injurious to health, with intent that the same may be sold in that state, and no person shall sell any article so treated.

No person shall, except for the purpose of compounding, mix, colour, stain, or powder, or permit any other person to mix, colour, stain, or powder, any drug so as to affect injuriously the quality or potency of such drug, with intent that the same may be sold in that state. Penalty for injurious admixture—first offence, £50; later, imprisonment with hard labour for a period not exceeding six months. There is no liability if the accused could not, "with reasonable diligence," know of the admixture, and was unaware of it. No person shall sell, to the prejudice of the purchaser, any article of food or any drug which is not of the nature, substance, and quality demanded. Penalty, £20. There is, however, no offence if non-injurious matter or ingredient is added—(*a*) in preparation for commerce and not fraudulently to increase measure; (*b*) where the drug or food is a proprietary medicine and supplied according to patent; (*c*) where the food or drug is compounded as allowed; (*d*) where the food or drug is unavoidably mixed with some extraneous matter in the process of collection or preparation. The onus of proving (*a*), (*b*), (*c*), or (*d*) rests with the accused. No person shall sell any compound, food, or drug, not having the ingredients asked for, unless it is labelled "mixed" at the time of sale. No person shall abstract from any article of food any part of it, so as to affect injuriously its quality, substance, or nature, or shall sell the same without disclosing the alteration. Penalty, £20. In any prosecution under this Act, the defendant is to be discharged if he proves to the satisfaction of the court—(*a*) that he bought the article as being the same in nature, substance, and quality with that demanded by the purchaser, and with a written warranty to that effect; (*b*) that at the time of sale he had no reason to believe it to be otherwise; (*c*) that he sold it in the same state as when he purchased it.

A public analyst may, and if required by the L.G.B., must, be appointed in every district, and any person paying a fee not exceeding 10s. 6d. can have any food or drug purchased in the district analysed, and receive a certificate from the public analyst as to the result of analysis. The C.C. appoint the public analyst, except in towns. In the latter the Town Council do so. The

M.O.H., S.I., or other person authorised by the L.A. may, by purchase, procure samples for analysis. Any person buying for analysis, on completion of the purchase, must forthwith notify the seller of his intention to have it analysed by the public analyst, and shall offer to divide it into three parts to be then and there separated, and each part to be marked and sealed and fastened up, and shall, if required to do so, proceed accordingly, and shall give one to the seller, one to the analyst, the third being kept for future comparison. If the offer is not accepted, the sample is to be divided by the analyst into two parts, and one of them sealed and delivered to the purchaser. Samples may be sent to the analyst by registered parcel post if his residence is two miles from that of the purchaser. Any person refusing to sell to an officer of the L.A. any article of food or drug on sale by retail, the price being tendered and a reasonable quantity demanded, is liable to a penalty not exceeding £10. The analyst's certificate must be in a prescribed form (set forth in a Schedule to this Act), and is sufficient evidence, unless the defendant requires the analyst to be called as a witness. The court may, on the request of either side, send a sample to Somerset House for analysis by chemists of the department of the Commissioners of Inland Revenue.

S.F.D.A.A.A., 1879.

This Act was passed to render more explicit certain clauses of the previous Act.

When bought for analysis, the article is still sold "to the prejudice of the purchaser." An article need only be defective in nature, or substance, or quality, and not in all three. The M.O.H., S.I., or constable charged with the execution of the Act may procure, at the place of delivery, a sample of milk in course of delivery to the purchaser or consignee, in pursuance of any contract; and may submit the sample to the public analyst.

The seller, or his representative, if he refuse to allow a sufficient sample to be taken, is liable to a penalty not exceeding £10. Whisky, brandy, or rum may be sold 25 degrees under proof, and gin 35 degrees under proof, if mixed only with water. In case of a perishable article, the summons must be served within twenty-eight days from the purchase.

S.F.D.A., 1899.

Precautions against the importation of agricultural and other produce insufficiently marked. If there is imported into the United Kingdom any of the following articles :—namely, (*a*) Margarine or margarine cheese, except in packages conspicuously marked "margarine" or "margarine cheese" as the case may require; or (*b*) adulterated or impoverished butter (other than margarine), or adulterated or impoverished milk or cream, except in packages or cans conspicuously marked with a name or description indicating that the butter or milk or cream has been so treated; or (*c*) condensed, separated, or skimmed milk, except in tins or other receptacles clearly labelled with the words, "machine-skimmed milk" or "skimmed milk"; (*d*) any adulterated or impoverished article of food . . . the importer shall be liable to fine. The word "importer" shall include any person who, whether as owner, consignor or consignee, agent, or broker, is in possession of, or in anywise entitled to, the custody or control of the article. An article of food shall be deemed to be adulterated or impoverished if it has been mixed with any other substance, or if any part of it has been abstracted so as in either case to affect injuriously its quality, substance, or nature. Provided that an article of food shall not be deemed to be adulterated by reason only of the addition of any preservative or colouring matter of such a nature and in such a quantity as not to render the article injurious to health. The Commissioners of Customs are the authority under this section of the Act, and they shall take samples, undertake prosecutions, etc., as required by its provisions.

The L.G.B. may, or in relation to the general interests of agriculture, the Board of Agriculture may, by an officer of the Board, take samples of food and submit them for analysis, according to the provisions of the S.F.D.A., 1875, except that—(*a*) The officer shall divide the sample into four parts, shall deal with three of them in the manner directed by the S.F.D.A., 1875, and shall send the fourth part to the Board. (*b*) The fee for analysis is payable by the L.A. of the place where the sample was procured. The Board shall intimate the result of such analysis to the L.A., who are to proceed as if they themselves had instituted the analysis.

The L.A. must appoint a public analyst, and put in force, from time to time, the powers with which they are invested. In case of their default, the L.G.B. or B. of A. may empower an officer to execute the provisions of the Act, and the L.A. must pay expenses. The B. of A. have power to make regulations determining the standard of purity of milk, cream, butter, or cheese. The provisions of the M.A., 1887 (p. 543), are extended to include margarine cheese, *i.e.* any substance, compound or otherwise, prepared in imitation of cheese, and containing fat not derived from milk, and shall apply accordingly with the substitution of "margarine cheese" and "cheese" for "margarine" and "butter" respectively. The letters required to be printed on the paper wrapper in which margarine or margarine cheese is sold, shall be capital block letters, not less than ½ in. long, and distinctly legible, and no other printed matter shall appear on the wrapper.

Wholesale dealers in, and manufacturers of, margarine or margarine cheese must keep registers showing the quantity and destinations of all consignments. The B. of A. have power through their officers to enter and inspect any manufactory of margarine or margarine cheese, and can take samples. Penalties are provided where a register is not kept, is not posted up to date, is not produced on demand, has false entries or fraudulent omissions. It is unlawful to manufacture, sell, expose for sale, or import any margarine, the fat of which contains more than 10 per cent. of butter-fat. Any person selling, by himself or another, in any highway or public place, milk or cream from a vehicle or receptacle, must have his name and address conspicuously inscribed on such vehicle or receptacle. Penalty for contravention, £2. In the case of a sample taken of milk in course of delivery, or of margarine or margarine cheese forwarded by a public conveyance, the person taking the sample shall forward . . . a portion of it marked, sealed, or fastened up to the consignor if his name and address appear on the can or package containing the article sampled. Tins or receptacles of condensed, separated, or skimmed milk must be plainly labelled "machine-skimmed milk," or "skimmed milk," as the case may require. Penalty, £10.

The label referred to in the S.F.D.A., 1875, must not have the notice of mixture obscured by any other matter on the label.

The provisions of the S.F.D.A., 1875, relating to the taking of samples of milk in course of delivery, are now extended to every other article of food, but no sample of the latter is to be taken, except upon the request or with the consent of the purchaser or consignee. A seller can only be required to sell in an unopened tin or packet any article of food or drug exposed for sale in an unopened tin or packet duly labelled. A sample for analysis *must* now be divided into three parts, and one must be given to the seller if required. There are fines of £20, £50, and £100 for first, second, and subsequent offences for any one obstructing an officer in the discharge of his duties or attempting to bribe him. Where a person guilty of an offence is liable to a penalty of £50, and, in addition, culpable negligence or personal default is proved, that person shall be liable to imprisonment for a period not exceeding three months, with or without hard labour. All prosecutions for sale must be made within twenty-eight days from the time of purchase. The summons, not to be returnable in less than fourteen days, must be accompanied by a copy of the analyst's certificate, particulars of the offence, and the name of the prosecutor. The defendant must notify within seven days if he relies on defence of "warranty," and must send to the purchaser a copy of warranty with the name and address of the giver of the warrant, and also notify his intention to the giver of the warrant. A warranty given by a person outside the United Kingdom does not avail for defence, unless the defendant prove that he believed it and took reasonable steps to ascertain its truth. Penalties are provided for a false warranty, unless the defendant proves that he believed it to be true. The court may send a sample for analysis to the Commissioners of Inland Revenue on its own initiative, and shall do so on the request of either party. Production, by the defendant, of the analyst's certificate is sufficient, unless the prosecutor desire the analyst to appear as a witness.

The 1899 Act repeals portions of other Acts, namely, the S.F.D.A., 1875; the S.F.D.A.A.A., 1879; and the M.A., 1887. In the first, the definition of food is repealed, and a new definition substituted. The division of the sample into three parts is rendered compulsory, the delivery of one part to the seller is compulsory if required, and the provisions with regard to false warranty are somewhat different.

In the second, the regulations governing the time of proceedings are altered; and in the third, there is a change rendering it necessary to deliver retailed margarine *in* a marked paper wrapper, and not merely accompanied by such a marked wrapper.

Margarine.

Acts Concerned.

M.A., 1887; S.F.D.A., 1899.

Application.—Great Britain and Ireland.

M.A., 1887.

Provisions.—This Act is for the purpose of "protecting the public against the sale as butter of substances made in imitation of butter, as well as of butter mixed with any such substances."

Butter is defined to mean "the substance usually known as butter, made exclusively from milk or cream, or both, with or without salt or other preservative, and with or without the addition of colouring matter."

Margarine shall mean all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not; and no such substance shall be sold, except under the name of margarine, and under the conditions set forth in this Act.

Penalties are provided for first and subsequent offences; but an employer charged with an offence against this Act is exempted from penalty if he can show that he used "due diligence to enforce the execution of the Act," and proves that another person committed the offence "without his knowledge, consent, or contrivance."

Every package, open or closed, containing margarine must be branded or durably marked "margarine" on the top, bottom, and sides, in printed capitals not less than $\frac{3}{4}$ in. square. If such margarine be exposed for sale retail, there shall be attached to each parcel, and clearly visible to the purchaser, a label marked "margarine," in printed capitals not less than $1\frac{1}{2}$ in. square; and margarine sold by retail must be delivered to the purchaser in or with a paper wrapper on which is printed the word "margarine" in capitals not less than $\frac{1}{4}$ in. square. A dealer in margarine charged with contravention of this Act may not be convicted if he prove that he purchased the article as butter, with a written warranty or invoice, that he had no reason to suppose that it was not butter, and that he sold it in the same state as he bought it. All margarine factories must be registered with the S.A. by whom the public analyst of the district is appointed. Officers authorised to take samples under the S.F.D.A. may take samples of butter, or reputed butter not marked margarine, without going through the form of purchase, and must deal with such samples as directed in the S.F.D.A. Any such substance not so marked is presumed to be exposed for sale as butter. Packages of margarine forwarded by public conveyance must be consigned as margarine, and authorised persons may take samples from any package.

S.F.D.A., 1899 (see pp. 541, 542).

Sale of Poisons.

Acts Concerned.

Sale of Arsenic Act, 1851; Sale of Poisons Act (Pharmacy Act), 1868; Pharmacy Act A. A., 1898 (unimportant).

Application.—Whole country.

SALE OF ARSENIC ACT, 1851.

This Act does not apply to arsenic when prescribed by a legally qualified medical practitioner. It requires that particulars be kept of each sale of arsenic, and that arsenic shall not be sold to a person unknown to the seller, unless a witness be present.

Arsenic must be mixed before sale with soot or indigo, in the proportion of 1 oz. of soot or $\frac{1}{2}$ oz. of indigo to 1 lb. of arsenic, unless such mixture would render the arsenic unfit for the purpose for which it is wanted. The penalty for contravention is a fine not exceeding £20.

PHARMACY ACT, 1868.

The sale of poison is unlawful except by a chemist or druggist registered under this Act. His apprentices must also be registered.

It is unlawful to sell any poison unless the box, bottle, vessel, wrapper, or cover be distinctly labelled with—(*a*) the name of the article; (*b*) the word "poison"; (*c*) the name and address of the seller of the poison. It is unlawful to sell any poison scheduled in Part I. of Schedule A. (see infra) to any person unknown to the seller, unless such person be introduced by some one known to the seller. Further, on every such sale the seller shall, before delivery, enter in a book—(1) the date of sale; (2) the name and address of the purchaser; (3) the name and the quantity of the article sold; (4) the purpose for which the article is required. To this entry the signatures of the purchaser and introducer shall be affixed.

If there be a poison ingredient in a medicine dispensed, the medicine must be labelled with the name and address of the seller, and the seller must enter in a book the ingredients of the medicine and the name of the person to whom it is sold or delivered.

Poisons within the meaning of this Act include those named in Schedule A, Parts I. and II., and any other article declared to be a poison by regulation of the Council of the Pharmaceutical Society, approved by Privy Council, and advertised in the *Gazette*.

SCHEDULE A.

PART I.

- Aconite and its preparations.
- *Alkaloids and all poisonous vegetable alkaloids and their salts.
- Arsenic and its preparations.
- *Atropine and its preparations.
- Cantharides.
- Corrosive sublimate.
- *Cyanide of potassium and all metallic cyanides and their preparations.
- Emetic tartar.
- Ergot of rye and its preparations.
- Prussic acid and its preparations.
- Savin and its oil.
- Strychnine and its preparations.
- *Vermin killers, if preparations of poisons, the preparations of which are in Part I. of this Schedule.

PART II.

- Almonds, essential oil of (unless deprived of Prussic acid).
- Belladonna and its preparations.
- *Cantharides, tincture, and all vesicating liquid preparations of.
- *Chloral hydrate and its preparations.
- Chloroform.
- *Corrosive sublimate, preparations of.
- *Morphia, preparations of.
- *Nux vomica and its preparations.
- Opium and its preparations, and preparations of poppies.
- Oxalic acid.
- *Precipitate, red (red oxide of mercury).
- *Precipitate, white (ammoniated mercury).
- *Vermin killers (see Part I.).
- *Compounds containing "poisons" prepared for the destruction of vermin, if not subject to the provisions of Part I., are in Part II.

Those substances marked * have been declared to be poisons at various times *since* the passing of the Act.

Dairies, Cow-sheds, and Milk-shops.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; M.F.F.C.A., 1847; C.D.(A.)A., 1878, 1886; I.D.P.A., 1890. In addition, L.G.B. Orders; D.C.M.O., 1885, 1886, 1899; Model Regulations of L.G.B., 1899.

P.H.A., 1875, ss. 116–119; and M.F.F.C.A., 1847, s. 15.

The provisions of these Acts in regard to unsound food apply to milk supplies (see p. 519).

C.D.(A.)A., 1878, s. 34, and 1886, s. 9.

Under these Acts the L.G.B. have power to make Orders for—"(1) The registration with the L.A. of all persons carrying on the trade of cowkeepers, dairymen, or purveyors of milk. (2) The inspection of cattle in dairies, and for prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cow-sheds in the occupation of persons following the trade of cowkeepers or dairymen. (3) Securing the cleanliness of milk-stores, milk-shops, and of milk vessels used for containing milk for sale by such persons. (4) Prescribing precautions to be taken for protecting milk against infection or contamination. (5) Authorising a L.A. to make regulations for the purposes aforesaid, or any of them, subject to such conditions, if any, as the Privy Council prescribe."

The power of entry possessed by the officers of the L.A. under the P.H.A., 1875, in regard to dairies, cow-sheds, and milk-shops, are the same as those in regard to nuisances, only differing in so far that, without special authority from the L.A. under the C.D.(A.)A., no person may "enter any cow-shed or other place in which an animal affected with any disease is kept, and which is situated in a place declared to be infected with such disease." The diseases included under the C.D.(A.)A. are cattle-plague, contagious pleuro-pneumonia, foot-and-mouth disease, sheep-pox, and sheep-scab, and any other disease which the Board of Agriculture may include in the term.

I.D.P.A., 1890 (see p. 523).

D.C.M.O., 1885, 1886.

S. 6.—(1) Cowkeepers, dairymen, and purveyors of milk must be registered. This does not apply to premises. (2) The S.A. must keep a register, revised and corrected, and regulate registration. (3) The S.A. shall register every such person, but the fact of such registration shall not be deemed to authorise such person to occupy as a dairy or cow-shed any particular building, or in any way preclude any proceeding being taken against him. (4) The S.A. shall from time to time give public notice of registration being required, and of the mode of registration. (5) The following are exempt from registration:—(*a*) Those making and selling butter and cheese only, and not purveying milk; (*b*) those only serving workmen and neighbours for their accommodation with small quantities of milk from their own cows.

S. 7.—It shall not be lawful to begin to occupy as a dairy or cow-shed any building not so occupied at the commencement of this Order, (1) until provision is made to the reasonable satisfaction of the S.A. for the lighting and ventilation, including air-space, and the cleansing, drainage, and water supply; (2) or without first giving one month's notice in writing to the S.A.

S. 8.—It shall not be lawful to occupy as a dairy or cow-shed any building, whether so occupied at the commencement of this Order or not, if . . . the lighting and ventilation, including air-space, and the cleansing, drainage, and water supply thereof, are not such as are necessary or proper—(*a*) for the health and good condition of the cattle therein; (*b*) for the cleanliness of milk vessels used therein for containing milk for sale; and (*c*) for the protection of the milk therein against infection or contamination.

S. 9.—It shall not be lawful for any . . . cowkeeper, or dairyman, or purveyor of milk, or occupier of a milk-shop—(*a*) to allow any person suffering from a dangerous infectious disorder, or having recently been in contact with a person so suffering, to milk cows, or to handle vessels used for containing milk for sale, or in any way to take part or assist in the conduct of the trade, . . . as far as regards the production, distribution, or storage of milk; or (*b*) if himself so suffering, or having recently been in contact as aforesaid, to milk cows or handle vessels containing milk for sale, or in any way to take part in the conduct of his trade, as far as regards the production, distribution, or storage of milk; until, in each case, all danger therefrom of the communication of infection to the milk or of its contamination has ceased.

S. 10.—No water-closet, privy, earth-closet, cesspool, or urinal must be within, or communicate directly with, or ventilate into any dairy or room used as a milk-store or milk-shop.

S. 11.—No milk store or shop is to be used as a sleeping apartment or for any other "contaminating" purpose.

S. 12.—Swine are not to be kept in the same building as cows, nor in any milk-store or other place used for keeping milk for sale.

S. 13.—Any S.A. may from time to time make regulations for the following purposes, or any of them:—(*a*) For the inspection of cattle in dairies; (*b*) for prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies and cow-sheds . . . ; (*c*) for securing the cleanliness of milk-stores, milk-shops, and milk vessels used for containing milk for sale; (*d*) for prescribing precautions to be taken by purveyors of milk, and persons selling milk by retail, against infection or contamination.

S. 14.—The following provisions shall apply to regulations made by any S.A. under this Order:—(1) Every regulation shall be published by advertisement in a newspaper circulating in the district of the S.A. (2) The S.A. shall send to the L.G.B. a copy of every regulation made by them not less than one month before the date named for such regulation to come into force. (3) If at any time the L.G.B. are satisfied on inquiry, with respect to any regulation, that the same is of too restrictive a character or otherwise objectionable, and direct the revocation thereof, the same shall not come into operation, or shall thereupon cease to operate, as the case may be.

S. 15.—The milk of a cow suffering from cattle-plague, pleuro-pneumonia, or foot-and-mouth disease—(*a*) shall not be mixed with other milk, and (*b*) shall not be sold or used for human food, and (*c*) shall not be sold or used for the food of animals, unless it has been boiled.

D.C.M.O., 1899.

This amends the Amending Order of 1886, and alters art. 15 just cited, so that now, as regards (*a*) and (*b*) thereof, the expressions in the said article which refer to disease include, in the case of a cow, such disease of the udder as shall be certified by a veterinary surgeon to be tubercular; and the Order and the Amending Order shall apply and be construed with the modification necessary to give effect to this article.

Penalties are imposed for contravening the Orders, but these do not apply to contraventions of the regulations made by the L.A., which should themselves contain penal clauses.

MODEL REGULATIONS OF THE L.G.B., 1899.

These are recommended to L.As. as the form which their regulations under the D.C.M.O. should take.

Definition.—1. The expression *cow-shed* includes any dairy in which milking cows may be kept; and the expression *cowkeeper* means any person following the trade of a cowkeeper or dairyman who is, or is required to be, registered under the D.C.M.O. of 1885.

2. Every occupier of a dairy wherein any cattle may be kept, and which the M.O.H., or the I.N., or any other officer of the Council specially authorised by them, may visit for the purpose of inspecting cattle, and every person for the time being having the care or control of any such dairy, or of any cattle therein, shall afford such M.O.H., I.N., or officer all reasonable assistance that may, for the purpose of the inspection, be required by him.

Part I.

The regulations in this part shall apply to cow-sheds, the cows from which are habitually grazed on grass-land during the greater part of the year, and when not so grazed, are habitually turned out during a portion of each day.

3. Every cowkeeper shall provide that every cow-shed in his occupation shall be sufficiently lighted with windows, whether in the sides or roof thereof.

4. Every cowkeeper shall cause every cow-shed in his occupation to be sufficiently ventilated, and for this purpose to be provided with a sufficient number of openings into the external air to keep the air in the cow-shed in a wholesome condition.

5. (*a*) Every cowkeeper shall cause every part of the interior of every cow-shed in his occupation to be thoroughly cleansed from time to time, as often as may be necessary to secure that such cow-shed shall be at all times reasonably sweet and clean.

(*b*) Such person shall cause the ceiling or interior of the roof and the walls of every cow-shed in his occupation to be properly limewashed twice, at least, in every year—that is to say, once during the month of May, and once during the month of October—and at such other time as may be necessary. Provided that this requirement shall not apply to any part of such ceiling, roof, or walls, that may be properly painted, or varnished, or constructed of, or covered with, any material such as to render the limewashing unsuitable or inexpedient, and that may be otherwise properly cleansed.

(*c*) He shall cause the floor of every such cow-shed to be thoroughly swept, and all dung and other offensive matter to be removed from such cow-shed as often as may be necessary, and not less than once in every day.

6. (*a*) Every cowkeeper shall cause the drainage of every cow-shed in his occupation to be so arranged that all liquid matter which may fall or be cast upon the floor may be conveyed by a suitable open channel to a drain inlet situate in the open air at a proper distance from any door or window of such cow-shed, or to some other suitable place of disposal which is so situate.

(*b*) He shall not cause or suffer any inlet to any drain of such cow-shed to be within such cow-shed.

7. (*a*) Every cowkeeper shall keep in, or in connection with, every cow-

shed in his occupation a supply of water suitable and sufficient for all such purposes as may from time to time be reasonably necessary.

(*b*) He shall cause any receptacle which may be provided for such water to be emptied and thoroughly cleansed from time to time, as often as may be necessary to prevent the pollution of any water that may be stored therein; and where such receptacle is used for the storage only of water, he shall cause it to be properly covered and ventilated, and so placed as to be at all times readily accessible.

Part II.

The regulations in Part I., and also the following regulation, shall apply to all cow-sheds other than those the cows from which are habitually grazed on grass-land during the greater part of the year, and, when not so grazed, are habitually turned out during a portion of each day.

8. A cowkeeper shall not cause or allow any cow-shed in his occupation to be occupied by a larger number of cows than will leave not less than 800 ft. of air-space for each cow.

Provided as follows:—

(*a*) In calculating the air-space for the purposes of this regulation, no space shall be reckoned which is more than 16 ft. above the floor; but if the roof or ceiling is inclined, then the mean height of the same above the floor may be taken as the height thereof for the purposes of this regulation.

(*b*) This regulation shall not apply to any cow-shed constructed and used before the date of these regulations coming into effect, until two years after that date.

Part III.

9. In this part the expression "*dairy*" means a dairy in which cattle are not kept.

10. Every cowkeeper shall provide that every dairy in his occupation shall be sufficiently lighted with windows, whether in the sides or roof thereof.

11. Every cowkeeper shall cause every dairy in his occupation to be sufficiently ventilated, and for this purpose to be provided with a sufficient number of openings into the external air to keep the air in the dairy in a wholesome condition.

12. (*a*) Every cowkeeper shall cause every part of the interior of every dairy in his occupation to be thoroughly cleansed from time to time, as often as may be necessary to secure that such dairy shall be at all times reasonably clean and sweet.

(*b*) He shall cause the floor of such dairy to be thoroughly cleansed with water at least once in every day.

13. (*a*) Every cowkeeper shall cause the drainage of every dairy in his occupation to be so arranged that all liquid matter which may fall or be cast upon the floor may be conveyed by a suitable open channel to the outside of such dairy, and may there be received in a suitable gully communicating with a proper and sufficient drain.

(*b*) He shall not cause or suffer any inlet to any drain of such dairy to be within such dairy.

14. (*a*) Every cowkeeper shall cause every dairy in his occupation to be provided with an adequate supply of good and wholesome water for the cleansing of such dairy, and of any vessels that may be used therein for

containing milk, and for all other reasonable and necessary purposes in connection with the use thereof.

(*b*) He shall cause every cistern or receptacle, in which any such water may be stored, to be properly covered and ventilated, and so placed as to be at all times readily accessible.

(*c*) He shall cause every such cistern or receptacle to be emptied and thoroughly cleansed from time to time, as often as may be necessary to prevent the pollution of any water that may be stored therein.

15. Every cowkeeper who is the occupier of a milk-store or milk-shop shall cause every part of the interior of such milk-store or milk-shop to be thoroughly cleansed from time to time, as often as may be necessary to maintain such milk-store or milk-shop in a thorough state of cleanliness.

16. (*a*) Every cowkeeper shall from time to time, as often as may be necessary, cause every milk vessel that may be used by him for containing milk for sale, to be thoroughly cleansed with steam or clean boiling water, and shall otherwise take all proper precautions for the maintenance of such milk vessel in a constant state of cleanliness.

(*b*) He shall, on every occasion when such vessel shall have been used to contain milk, or shall have been returned to him after having been out of his possession, cause such vessel to be forthwith so cleansed.

17. (*a*) Every purveyor of milk, or person selling milk by retail, shall take all reasonable and proper precautions in, and in connection with, the storage and distribution of milk, and otherwise to prevent the exposure of the milk to any infection or contamination.

(*b*) He shall not deposit or keep any milk intended for sale—(1) in any room or place where it would be liable to become infected or contaminated by impure air, or by any offensive, noxious, or deleterious gas or substance, or by any noxious or injurious emanation, exhalation, or effluvium; or (2) in any room used as a kitchen or as a living-room; or (3) in any room or building, or part of a building, communicating directly by door, window, or otherwise with any room used as a sleeping-room, in which there may be any person suffering from any infectious or contagious disease, or which may have been used by any person suffering from any such disease, and may not have been properly disinfected; or (4) in any room or building, or part of a building, in which there may be any direct inlet to any drain.

(*c*) He shall not keep milk for sale, or cause or suffer any such milk to be placed in any vessel, receptacle, or utensil which is not thoroughly clean.

(*d*) He shall cause every vessel, receptacle, or utensil used by him for containing milk for sale, to be thoroughly cleansed with steam or clean boiling water after it shall have been used, and to be maintained in a constant state of cleanliness.

(*e*) He shall not cause or suffer any cow belonging to him, or under his care or control, to be milked for the purpose of obtaining milk for sale—(1) unless, at the time of milking, the udder and teats of such cow are thoroughly clean; and (2) unless the hands of the person milking such cow are also thoroughly clean and free from all infection and contamination.

18. Every person who shall offend against any of the foregoing regulations shall be liable for every such offence to a penalty of £5, and in the case of a continuing offence to a further penalty of 40s. for each day after written notice of the offence from the Council.

Provided, nevertheless, that the justices or court before whom any complaint may be made, or any proceedings may be taken, in respect of any such offence, may, if they think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this regulation.

LONDON.

Acts Concerned.

L.G.A., 1899; P.H.(London)A., 1891; C.D.(A.)A., 1878, 1886. In addition, D.C.M.O. and Model Regulations of L.G.B.

Though the Acts concerned differ slightly, the law is the same as in England and Wales.

SCOTLAND.

Acts Concerned.

P.H.(S.)A., 1897; C.D.(A.)A., 1878, 1886. In addition, D.C.M.O. and Model Regulations of L.G.B.

The provisions of the P.H.(S.)A., 1897, will be found on p. 593.

IRELAND.

Acts Concerned.

C.D.(A.)A., 1878, 1886; D.C.M.O. (Ireland), 1879; P.H.(I.)A., 1878.

The law in Ireland is much the same as in England, but the D.C.M.O. of Ireland do not contain any clause forbidding contiguity between sanitary conveniences and dairies, and the regulations of S.As. are not subject to provisions similar to those of s. 14 of the English D.C.M.O.

Crabs and Lobsters.

Act Concerned.

CRAB AND LOBSTER ACT.

Application.—Great Britain and Ireland.

Provisions.—No crab may be offered for sale which is less than $4\frac{1}{4}$ in. across the back, and no lobster less than 8 in. from back to tail when extended flat. No crab may be consigned for sale with spawn outside attached to its tail; but there is no such restriction in the case of lobsters.

Housing of the Working-Classes.

Acts Concerned.

H.W.C.A., 1890, 1894, 1900.

Application.—Whole country.

H.W.C.A., 1890.

This Act concentrates and improves the provisions of various prior Acts, and deals with artisans' and labourers' dwellings, and with houses of the working-classes. It is divided into 7 parts, 3 main, 1 supplemental, and 3 others accessory, but unimportant.

UNHEALTHY AREAS.

PART I. deals with unhealthy areas, improvement schemes, and similar matters. It does not apply to R.S.D.

The L.A., on consideration of, and being satisfied by, an official representation of the unhealthiness of any area, must, provided that their resources are sufficient, initiate a scheme for its improvement. Such official representation is the duty of the M.O.H. of the L.A., and must set forth—(*a*) that houses, courts, or alleys are unfit for human habitation; or (*b*) that the narrowness, closeness, and bad arrangement, or the bad condition of the streets and houses, or groups of houses within such area, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defects, or one or more of such causes, are dangerous or injurious to the health of the inhabitants either of the buildings in the said area or of the neighbouring buildings. Further, the official representation must state that the evils and sanitary defects mentioned cannot be effectually remedied otherwise than by an improvement scheme for rearrangement and reconstruction of the streets and houses, or of some of them, within such area. The L.A. may pass a resolution declaring that such area is an unhealthy area, and that an improvement scheme ought to be made in respect of it. Thereafter the L.A. must proceed forthwith to make a scheme for the improvement of such area.

The M.O.H. may make an official representation whenever he sees cause, but if two justices or twelve ratepayers of the district complain to him of the unhealthiness of any area, he must at once inspect such area and make a representation giving his opinion on the matter. If the M.O.H. fail to do so, or if he assert that the area is not unhealthy, the ratepayers may appeal to the L.G.B., who may appoint an inspector to make special inquiry, and report to them. This report is sent by the L.G.B. to the L.A., and must be treated by the L.A. as an official representation. If the L.A. passes no resolution, or disapproves of the official representation of their M.O.H., they must forward a copy of the latter and of their reasons for disapproval to the L.G.B., and the L.G.B. may order a local inquiry. The scheme may provide for the reconstruction and rearrangement of streets and houses within the area, for the widening of approaches to improve ventilation, and for the general opening out of the area, also for the provision of proper sanitary conveniences, and for housing those persons displaced. Due publicity must be given to the scheme by newspaper advertisement, and notices must be served on all persons interested. The L.A. then apply to the L.G.B. for a Provisional Confirmation Order; the L.G.B. then hold a local inquiry as to the correctness of the official representation and the sufficiency of the scheme, and the L.G.B. may grant the Order, which requires to be ratified by Act of Parliament.

Compensation for compulsory purchase under such a scheme is based on market value without any addition, such as 10 per cent. for compulsory purchase.

LONDON.

The official representation in London may be made to the L.C.C. by any M.O.H. of a district, as well as by the M.O.H. of the C.C. The Home Secretary, and not the L.G.B., is the confirming authority. The scheme must provide accommodation in or near the area for all persons displaced, but this requirement is subject to qualification in the Order.

UNHEALTHY DWELLING-HOUSES.

Part II.—This part of the Act applies to both U. and R.S.D.

Definitions.—*Street* includes any court, alley, street, square, or row of houses. *Dwelling-house* means any inhabited building, and includes any yard, garden, outhouses, appurtenances, belonging thereto or usually enjoyed therewith, and the site of the dwelling-house as so defined. *Owner*, in addition to the definition given by the Lands Clauses Acts, includes all lessees or mortgagees of any premises required to be dealt with under this part of this Act, except persons holding or entitled to the rents and profits of such premises for a term of years of which twenty-one years do not remain unexpired. *Closing order* means an order prohibiting the use of premises for human habitation.

Provisions.—The M.O.H. must make a representation to the L.A. concerning any dwelling-house which appears to him to be in a state so dangerous or injurious to health as to be unfit for human habitation; and the M.O.H. may inspect any such house, either on his own initiative, or at the instigation of four or more householders making a written complaint to him. If an U.S.A. fail to act on the representation within three months, the complainant householders may appeal to the L.G.B., who may order an inquiry, and compel the L.A. to proceed. Every L.A. must from time to time inspect the dwelling-houses in their district, and if any dwelling-house appears to them to be in a state so dangerous or injurious to health as to be unfit for human habitation, the L.A. must forthwith take proceedings against the owner or occupier. Such proceedings are governed by clauses 91 (1), 94, 95, and 97 of the P.H.A., 1875 (p. 511), and have for their object the closing of the house.

Occupied houses may be closed, as well as unoccupied houses, and in the case of the former, the L.A. must serve a notice on the occupying tenants that such a closing order has been made by the court. The owner may be ordered to render the house fit for human habitation. If this is not done, and if the L.A. consider that the building is dangerous or injurious to the health of the public, or of the neighbouring inhabitants, the L.A. must pass a resolution that it is expedient to order the demolition of the building, and must serve a notice of such resolution on the owner, who is entitled to appear and state his objections to such demolition. The L.A. must order the demolition of the building, if, after consideration of the resolution and objections, they still consider such a course expedient, unless the owner undertakes forthwith to remedy the defects, and does so remedy them within a specified time. If the L.A. make a demolition order, the owner must comply with it within three months; and in default, the L.A. may themselves do so, sell the materials, deduct their expenses, and pay the balance to the owner. No building so demolished may be replaced by any other similarly dangerous or injurious to health.

This part of the Act also refers to "obstructive buildings," *i.e.* those buildings which, though not themselves unfit for human habitation, are yet so situated as to stop the ventilation or otherwise conduce to render other buildings insanitary, or to prevent the remedying of nuisances. The M.O.H. must, and four householders may, make a representation to the L.A. advising that the obstructive building should be pulled down.

The L.A. must then make inquiries as to the facts and the cost of taking action, and may order the building to be pulled down. The owner of the obstructive building is entitled to be heard by the L.A. before any order is made, and may appeal against such order; but if he do not so appeal, or fail in the appeal, the L.A. may purchase the land on which the building is erected, the price being settled by arbitration or agreement. Any person aggrieved may appeal to a Court of Quarter Sessions against any order made by a L.A. under Part II. of the Act.

IMPROVEMENT SCHEMES.

The L.A. may, under this part of the Act, frame a scheme for reconstruction or improvement in respect of unhealthy dwelling-houses ordered to be demolished, and also of small unhealthy areas not conveniently dealt with under Part I. The scheme may include clearing away of such dwellings, extension of open spaces, widening of streets, rearrangement of buildings, and the provision of dwellings for the working-classes. The procedure is the same as under Part I. in respect of application to the L.G.B., local inquiry, and provisional order. It differs only in the fact that such order does not require ratification by Parliament unless the land is to be acquired by compulsory purchase.

The L.A. must furnish the L.G.B. with an annual report of their proceedings and financial transactions in carrying out this part of this Act, and R.S.As. must notify the C.C. of any proceedings under this part of the Act. If the C.C. consider that the Act should be put in force with regard to any buildings, and if the L.A. after due notice fail to do so, the C.C. may take over and exercise the powers of the L.A. The M.O.H. of the C.C. may report to the C.C. concerning any buildings within his district, but not in a borough, and the C.C. may forward his representation to the R.S.A., who must act upon it as upon a similar representation from the M.O.H. of their district. Where a L.A. merely desires to close an unhealthy house, the procedure is taken under the P.H.A.; but where demolition is the ultimate aim, the procedure is taken under this Act.

LONDON.

This part of the Act is under the administration of the Borough Councils, but the L.C.C. also has power to frame schemes under it, and the expenses may be jointly borne by the central and district authorities. The Metropolitan Borough Councils must inform the L.C.C. of any representation, complaint, information, or closing order, and any further proceedings under this Act, and the L.C.C. may require the district authority to take such further measures as may be necessary, and in default may themselves exercise the powers of such local authorities.

SCOTLAND.

The provisions apply in the same way as in England, but the C.C. cannot take over the powers of a defaulting L.A.

IRELAND.

The Act applies as in England, with the exception of those portions referring to C.C.

WORKING-CLASS LODGING-HOUSES.

Part III. (Adoptive).—This part of the Act may be adopted by U.S.As. with the approval of the L.G.B., and by R.S.As. after inquiry by and certificate from the C.C. The expression *lodging-houses for the working-classes* in this part of the Act includes separate houses or cottages for the working-classes, whether containing one or several tenements. The term *cottage* may include a garden of not more than half an acre, provided the estimated annual value of such garden does not exceed £3.

Land may be acquired by a L.A. either by agreement or compulsory purchase. On this land the L.A. may erect lodging-houses for the working-classes, or may convert any building into such houses, and may alter, repair, fit and furnish the same. The L.A. may purchase or lease lodging-houses already built, or about to be built, or may undertake the management of such. The L.A. may make by-laws for the general management, regulation, and control of such buildings, and, except in the case of lodging-houses occupied as separate dwellings, such by-laws must provide for the following purposes:—(1) For securing that the lodging-houses shall be under the management and control of the officers, servants, or others appointed or employed in that behalf by the authority; (2) for securing the due separation at night of men and boys above 8 years old from women and girls; (3) for preventing damage, disturbance, or interruption, and indecent or offensive language and behaviour, and nuisances; (4) for determining the duties of the officers, servants, and others appointed by the authority.

These lodging-houses are not to be used by persons in receipt of parochial relief, and such relief, except for accident or temporary illness, disqualifies a tenant.

These lodging-houses must be always open to inspection by the officers of the L.A. of the district.

The expenses of carrying out this part of the Act come out of the rates in U.S.D., and in R.S.D. out of special contributions, or are paid as general expenses under the P.H.A. The L.A. may give these lodging-houses a seven years' trial, and if then found too expensive, the L.A. may sell them, the U.S.A. requiring the consent of the L.G.B., and the R.S.A. that of the C.C.

LONDON.

The authority in London is the L.C.C., except in the City, where the Commissioners of Sewers may adopt this part of the Act.

SCOTLAND.

Both U.S.As. and R.S.As. require the consent of the L.G.B. before the adoption of Part III.

IRELAND.

Municipal town authorities may adopt this portion of the Act, but to their dealings with land, the acquisition of lodging-houses, etc., the consent of the Treasury is required. Rural Authorities seldom require to adopt it, as the erection of houses for agricultural labourers by any R.S.A. is provided for in the numerous Labourers (Ireland) Acts.

Part IV.—Supplemental.—In this portion it is enacted that in any contract for letting, for habitation by persons of the working-classes, any house, or part of a house, there shall be implied a condition that the house is at the commencement of the holding in all respects reasonably fit for human habitation. This proviso is limited to houses under a certain rateable value.

H.W.C.A., 1894.

This relates to Part II. of the 1890 Act, and deals with the borrowing of money by the L.A.

H.W.C.A., 1900.

By this Act the L.A. obtains power to acquire land outside their own district for the purpose of providing lodging-houses for the working-classes.

Canal Boats.

Acts Concerned.

Canal Boats Acts, 1877, 1884. In addition, Regulations of L.G.B., 1878.

Application.—England and Wales, including London, but the Acts do not apply to Scotland and Ireland.

Provisions.—Every canal boat used as a dwelling-house must be registered with the L.A. as a dwelling intended for a certain number of persons of specified age and sex, who alone may occupy it. The registration authority is any S.A. whose district abuts on the canal on which the canal boat plies, or is intended to ply. The boat must be registered as belonging to some place within the said district. The original register is recognised as being in force upon all other canals whereon the boat may ply. On registration, the owner must be provided by the L.A. with two copies of a certificate :—(*a*) Identifying the owner and the boat ; (*b*) stating the place to which it belongs ; (*c*) setting forth the number, age, and sex of the persons permitted to dwell in the boat. The master of the boat must carry one of these certificates. The boat is not considered registered unless it is marked with—(1) the name of the place to which it belongs ; (2) its number ; (3) the word "registered," and these marks must be plainly visible, and on both sides of the boat, or so placed as to be seen from either side. Any structural alterations in the boat, which affect the conditions on which it was originally registered, nullify the certificate. A boat ceasing to be used as a habitation is no longer subject to the Acts. A canal boat used in contravention of the Acts renders its master and its owner, if he be at fault, each liable to a penalty. If the M.O.H., or other medical practitioner, certify to the S.A. that any person in a canal boat is suffering from infectious disease, this S.A., being that of the place where the boat is, must take the necessary precautions, may remove such sick person, take other action under the P.H.A., 1875, and the I.D.P.A. if adopted, and may detain the boat as long as necessary for cleaning and disinfection. Powers of entry between 6 a.m. and 9 p.m. are conferred upon any person authorised by the S.A. In the event of suspected contraventions of the Act, or the presence of infectious disease, the master may be called upon to produce the certificate of registry of the boat, and there is a penalty for obstruction. The Act directs the L.G.B. to issue regulations concerning canal boats, and consequently the

Board issued an Order in 1878 prescribing regulations, which are here summarised.

There must be at least one dry, clean, and weather-proof cabin in good repair. An after-cabin used as a dwelling must contain not less than 180 cubic ft. of free air-space, and a fore-cabin 80 cubic ft. Every such cabin must have adequate ventilation and sleeping accommodation. One cabin must contain a stove and chimney. There must be storage for 3 gallons of water. If the boat usually carries foul cargoes, the hold must be separated from any inhabited cabin by a double bulkhead, with an interspace of 4 in., the bulkhead next the cargo being watertight; the space must be open throughout to the external air, and must be provided with a pump for the removal of any liquid from such space. Not less than 60 cubic ft. of air-space per head for persons over 12 years, and 40 cubic ft. per head for children under that age, must be provided. In "fly boats," worked by shifts, a cabin occupied at the same time by two persons, must have a capacity of 180 cubic ft. A cabin in which a married couple sleep must not be occupied at the same time by any other male above 14, or female above 12 years of age. Males over 14 and females over 12 must not sleep in the same cabin unless married. The interior of the cabin must be repainted every three years, and kept clean. Bilge-water must be pumped out daily. The master of the boat must at once notify the occurrence of any case of infectious disease on the boat to the S.A. of the district in which the boat is, and also to the S.A. of the place of destination. He must also inform the owner, who, in his turn, must notify the S.A. of the place to which the boat belongs. If the boat is detained for disinfection, he may not proceed till he has obtained a certificate from the S.A., submitted to them by a medical man.

The S.A. may pay a reasonable remuneration for such certificate.

Moveable and Temporary Dwellings.

ENGLAND AND WALES.

ACTS CONCERNED.

P.H.A., 1875; H.W.C.A., 1885; P.H.(Fruit Pickers' Lodgings)A., 1882.
In addition, Model By-laws (2 sets).

P.H.A., 1875.

Provisions.—S. 314.—This confers powers on L.As. to make by-laws for securing the decent lodging and accommodation of hop-pickers within their district.

P.H.(F.P.L.)A., 1882.

This Act permits L.As. to make similar by-laws for identical objects in the case of fruit and vegetable pickers. The Model By-laws of the L.G.B. are, briefly, as follows:—

The habitations must be clean, dry, weather-proof, ventilated, and lighted. Each adult must be allowed 16 square ft. of floor space, and so must every two children under 10 years of age. Screens or partitions must be provided to secure privacy where adults of different sexes are accommodated. A separate cooking-place is required for every fifteen persons. A sufficient supply of good water for drinking, cooking, and washing, and adequate privy accommodation for the separate use of each sex, must be provided, as must a sufficient supply of clean straw or other dry bedding, which must be changed or cleansed as occasion may require. The premises must be kept clean, the internal surfaces limewashed at least once a year, and all offensive accumulations must be removed.

H.W.C.A., 1885.

Ss. 9 and 10.—A tent, van, shed, or similar structure, used for human habitation, which is in such a state as to be a nuisance, or injurious to health, or which is so overcrowded as to be injurious to the health of the inmates, whether or not members of the same family, shall be deemed to be a nuisance within the meaning of s. 91, P.H.A., 1875, and the provisions of that Act shall apply accordingly (p. 511). Any S.A. may make by-laws for promoting cleanliness in, and the habitable condition of such habitations, and for preventing nuisances and the spread of infectious disease. Powers of entry between 6 a.m. and 8 p.m. are provided, whereby any person authorised by the S.A., or by a justice of the peace, may enter to investigate either suspected contraventions of the Act or by-laws, or the presence of dangerous infectious disorder. There is a penalty provided for obstruction.

MODEL BY-LAWS OF 1899.

Vans used for human habitation must be kept thoroughly clean inside, and adequate means of permanent ventilation must be provided for vans, sheds, or similar structures used for such habitation. Tents, vans, sheds, etc., must be maintained weather-proof, and suitable dry flooring or ground covering must be provided for tents, sheds, etc. Sufficient covered, accessible receptacles, kept clean and in good order, must be provided for the storage of water for tents, vans, sheds, etc., and a sufficient supply of wholesome water must be provided for the use of the inmates. Notice must be given to the M.O.H. of an infectious disease affecting any of the inmates. The infectious diseases specified are those mentioned in the I.D.N.A., with the addition of measles. All precautions ordered by the M.O.H. are to be observed, and no person, other than an attendant, may share such a structure with the sick person. No tent or van may be removed from the district until it shall have been disinfected, nor change its location in the district so as to spread infection. At the end of the case, whether by removal to hospital, recovery, or death, notice must be given to the M.O.H., who must have the tent, van, etc., and its contents thoroughly cleansed and disinfected, and no such van may be reoccupied till after such disinfection. Receptacles for refuse must be provided and cleansed after use, and no accumulation of solid or liquid filth must be allowed within the structure, or within 30 ft. thereof, so as to cause a nuisance. No animal must be kept, and no deposit of filth or dung must be permitted, within 40 ft. of any water supply. Penalties are provided, and the carrying out of all these requirements rest with the occupier.

LONDON.

Acts Concerned.

The same as above, with the substitution of s. 95, P.H.(London)A., 1891, for s. 91, P.H.A., 1875.

SCOTLAND.

Acts Concerned.

H.W.C.A., 1885; P.H.(S.)A. 1897.

This subject is governed by the latter Act, and the provisions applying will be found on p. 596. The former Act may or may not be in force, as the section applying it to Scotland was in that part of the Act since repealed; in any case it is unnecessary, as the latter Act contains similar provisions.

IRELAND.

Acts Concerned.

H.W.C.A., 1885; P.H.(I.)A., 1878.

As in Scotland, the former Act is only of doubtful force.

Baths and Wash-houses.

ENGLAND AND WALES.

Acts Concerned.

Baths and Wash-houses Acts, 1846, 1847, 1878, 1882 (all adoptive); P.H.A., 1875. In addition, Model By-laws.

P.H.A., 1875.

S. 10 confers on U.S.As. power to adopt the Baths and Wash-houses Acts, and to form, maintain, regulate, and manage baths and wash-houses within their district. In rural districts the parish meeting may adopt the Acts, and the Parish Council is the authority invested with control. Regulating by-laws may be issued by the controlling authority, and the L.G.B. have framed Model By-laws for these matters.

LONDON.

Acts Concerned.

Baths and Wash-houses Acts, as above; also Baths and Wash-houses Act, 1895. In addition, Model By-laws.

The Commissioners of Sewers may adopt the Act, and control baths and wash-houses in the City of London. Elsewhere the Borough Councils, with the consent of the L.G.B., are the adopting authorities, and the control is vested in commissioners appointed by the Borough Councils from among the ratepayers.

SCOTLAND.

Acts Concerned.

B.P.(S.)A., 1892; P.H.(S.)A., 1897; L.G.A., 1894.

B.P.(S).A.

Ss. 309 to 314 authorise Town Commissioners to provide and control baths and wash-houses, and these clauses may be adopted also by special districts formed under the L.G.A., 1894, for the provision of baths and wash-houses. By the P.H.(S.)A., 1897, s. 126, the L.A. may give a gratuitous supply of water to public baths and wash-houses if not established for private profit, or supported out of the rates (p. 606).

IRELAND.

Acts Concerned.

Baths and Wash-houses (Ireland) Act, 1846; P.H.(I.)A., 1878; T.I.C.A., 1847, 1854.

The regulations in towns are similar to those in England, but in rural districts the power of providing baths and wash-houses is limited to such municipal towns as do not possess the power as U.S.Ds.

Cleansing of Persons.

Acts Concerned.

CLEANSING OF PERSONS ACT, 1897.

Application.—England and Wales, London, Scotland, and Ireland.

Provisions.—L.As. may permit any person infested with vermin to have the use, free of charge, of any apparatus which the L.A. possess, for cleansing the person and clothing from vermin. The use of such apparatus shall not be considered parochial relief or charitable allowance to the person using the same, nor to the parent of such person. L.As. may expend any reasonable sum on buildings, appliances, and attendants that may be required for carrying out the Act.

In *Scotland* and *Ireland* the sanction of the L.G.B. is required for the erection of any building for such a purpose by the L.A.

Burial Grounds and Cemeteries.

ENGLAND AND WALES AND LONDON.

Acts Concerned.

P.H.(Int.)A., 1879; Burial Act, 1853; P.H.A., 1875; Disused Burial Grounds Act, 1884. In addition, Regulations issued by the Home Secretary; Model By-laws of the L.G.B.; Memorandum of the L.G.B.

P.H.(INT.)A., 1879.

Both U. and R.S.As. may provide cemeteries for their districts, and must do so when required by the L.G.B., but the cemetery need not be within the district of the S.A. By memorandum the L.G.B. have specified the conditions under which the S.A. must take action. These are—(1) Wherein any burial ground, which remains in use, there is not proper space for burial, and no other suitable burial ground has been provided. (2) Where the continuance in use of any burial ground (notwithstanding there may be such space) is, by reason of its situation in relation to the water supply of the locality, or by reason of any circumstance whatsoever, injurious to the public health. (3) Where, for the protection of the public health, it is expedient to discontinue burials in a particular town, village, or place, or within certain limits.

The construction of a cemetery is forbidden within 200 yds. of any dwelling without the consent of the owner and occupier. There is no restriction if such consent be obtained, nor any prohibition of future building nearer to the cemetery, which must be enclosed and fenced, and consecrated ground defined.

BURIAL ACT, 1853.

A L.A. desirous of closing a burial ground must make representation to the Home Secretary and obtain an Order in Council to that effect.

P.H.A., 1875.

Interments underneath or within the walls of a church built after 1848 are forbidden.

D.B.G.A., 1884.

No building may be erected upon any disused burial ground, except for the purpose of enlarging a place of worship.

PROVISION OF BURIAL GROUNDS.

These may provided in two ways :—

I. By a Burial Board under the Burial Act. Regulations for these are issued by the Home Secretary.

1. The burial ground shall be effectually fenced, and, if necessary, underdrained to such a depth as will prevent water remaining in any grave or vault.

2. The area to be used for graves shall be divided into grave spaces, to be designated by convenient marks, so that the position of each may be easily determined, and a corresponding plan kept, on which each grave shall be shown.

3. The grave spaces for the burial of persons above 12 years of age shall be at least 9 ft. by 4 ft., and those for the burial of children under 12 years of age 6 ft. by 3 ft., or if preferred, half the measurement of the adult grave space—namely, $4\frac{1}{2}$ ft. by 4 ft.

4. A register of graves shall be kept, in which the name and date of burial in each shall be duly registered.

5. No body shall be buried in any vault or walled grave unless the coffin be separately entombed in an air-tight manner, that is, by properly cemented stone or brickwork, which shall never be disturbed.

6. One body only shall be buried in a grave at one time, unless the bodies are those of members of the same family.

7. No unwalled grave shall be reopened within fourteen years after the burial of a person above 12 years of age, or within eight years after the burial of a child under 12 years of age, unless to bury another member of the same family, in which case a layer of earth not less than 1 ft. thick shall be left undisturbed above the previously buried coffin ; but if on reopening any grave the soil is found to be offensive, such soil shall not be disturbed, and in no case shall human remains be removed from the grave.

8. No coffin shall be buried in any unwalled grave within 4 ft. of the ordinary level of the ground, unless it contains the body of a child under 12 years of age, when it shall not be less than 3 ft. below that level.

II. By the L.A. under the P.H.(Int.)A. The L.A. issues by-laws regulating burial grounds under the P.H.A., 1875, s. 141, and these are modelled on the Model By-laws of the L.G.B., which are as follows :—

Definitions.—(*a*) A *grave* is defined as a burial-place formed in the ground by excavation, and without any internal wall of brickwork or stonework, or any other artificial lining. A *vault* is an underground burial-place of any other construction.

(*b*) *Vaults.*—Every vault shall be enclosed with walls of brick or stone, solidly put together with good mortar or cement.

(*c*) *Common graves.*—Not more than one body shall be buried at any one time in a grave in respect of which no exclusive right of burial has been granted. (Exception is made in the case of two or more members of the same family.)

Such a grave shall not be reopened for the purpose of a further burial within eight years after the burial of a person aged less than 12 years, or within fourteen years after the burial of a person aged more than 12 years. (Exception is made in the case of members of the same family.)

(*d*) *Minimum covering of earth.*—No part of a coffin shall be buried at a less depth than 3 ft. below the ground adjoining the grave, if it contains the body of a person aged less than 12 years; nor at a less depth than 4 ft., if the age of the deceased was over 12 years. A layer of earth, not less than 1 ft. in thickness, shall be interposed between every coffin and the coffin nearest to it.

(*e*) *Closure of vaults.*—A coffin buried in a vault shall, within . . . hours after burial, be wholly and permanently embedded in and covered with good cement concrete, not less in any part than . . . inches in thickness; or wholly and permanently enclosed in a separate cell, constructed of slate or of flag, not less than 2 in. thick, and jointed in cement, or of brick in cement, and in such a manner as to prevent, as far as practicable, the escape of noxious gas.

SCOTLAND.

Acts Concerned.

B.G.(S.)A., 1885; P.H.(S.)A., 1897.

If any burial ground be a nuisance, it can be dealt with under the P.H.(S.)A., 1897 (p. 582). Alternatively, procedure may take place under the B.G.(S.)A., in which case the L.G.B., the L.A., the P.C., any two members of the P.C., ten ratepayers, or two householders resident within 100 yds. of the burial ground, or proposed burial ground, may apply to the sheriff, who must make inquiry, and if he finds that the burial ground, or proposed burial ground, is or would be dangerous to health, or offensive or contrary to decency, he must pronounce an interlocutor to that effect, and transmit a copy thereof to the Secretary for Scotland. Thereafter, an Order in Council may be issued closing the burial ground complained of, or prohibiting the opening of a new burial ground within certain limits. By this same Act certain L.As. may, and under certain conditions must, provide for—(*a*) closure of an existing burial ground; (*b*) supplying a new burial ground, if such be applied for by ten ratepayers or two parish councillors. If, after such application, nothing be done within six months, the applicants may apply to the sheriff, who, after inquiry and intimation, may designate a burial ground. The burial ground may not be within 100 yds. of any dwelling without the consent of the owner of such dwelling, and the burial ground need not be within the parish which it is intended to serve. Councils of different districts may combine for the purpose of providing a burial ground. An existing burial ground may be purchased, or the council may contract for the right of interment in any existing burial ground. The management of a burial ground is entrusted to the Town Council or the Parish Council, as the case may be.

It is to be noted that a L.A. may obtain the closure of an undesirable burial ground under either of the above Acts, and that if the action be taken under the B.G.(S.)A., it is the duty of the P.C. to provide a new burial ground; but under the P.H.(S.)A. there is no such obligation.

IRELAND.

Acts Concerned.

P.H.(I.)A.

The P.H.(Int.)A. does not apply, but, on representation being made, the L.G.B. may restrain the opening of new burial grounds and order discontinuance of burials in specified places. The Burial Boards are in towns the Guardians of the Poor, and elsewhere the same as S.As. If a burial ground be closed by order, the Burial Board has power to provide a suitable cemetery, and purchase land compulsorily, subject to the regulations of the L.G.B.

River Pollution.

ENGLAND, WALES, AND LONDON.

Acts Concerned.

R.P.P.A., 1876, 1893; D.(A.)A., 1894; P.H.A.A.A., 1890, Part III. (adoptive); L.G.A., 1888.

R.P.P.A.

Provisions.—This Act provides for the prevention of river pollution, and especially the establishment of new sources of pollution. It deals with the sources of pollution in four classes—(1) Solid matters; (2) sewage; (3) trade effluents; (4) mining effluents.

No solid refuse may be put into a stream so as to interfere with its due flow or pollute its waters. The solid refuse includes refuse from any manufactory, manufacturing process, or quarry, or any rubbish or cinders, or any other waste or putrid solid matter. No solid or liquid sewage may be passed into any stream unless it were done prior to 1876, in which case it may be continued if the best practicable and available means are taken to render the sewage harmless.

The R.P.P.A., 1893, provides that where any sewage matter reaches any stream after passing through or along any channel vested in a S.A., the S.A. is deemed knowingly to permit the sewage so to reach the stream. No poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process may be passed into any stream unless the best practicable and available means are taken to render it harmless. Innocuous discoloration of such liquid is not deemed *polluting*.

No solid matter from mines may be put into any stream in such quantity as to prejudicially interfere with its due flow; and no poisonous, noxious, or polluting solid or liquid matter from mines may be put into any stream other than water in the same condition in which it has been raised or drained from such mine. The saving clause also applies to this section. With regard to (1) and (2), proceedings may be instituted by any person or L.A. aggrieved; but as to (3) and (4), the L.A. only can take action, and this subject to the approval of the L.G.B., who must be satisfied that no material injury to industry will be done, and that there are available means of rendering the effluent safe. Any person interested can appeal to the L.G.B. to order a L.A. to proceed.

Definitions.—The word *stream* includes the sea to such extent, and tidal waters to such point, as the L.G.B. may determine, and rivers, streams, canals, lakes, and watercourses. *Solid matters* shall not include particles of matter in suspension in water.

D.(A.)A.

It is unlawful to throw into any river, stream, canal, or other water, or into the sea within 3 miles of the shore, the carcase of any animal which has died of disease.

P.H.A.A.A.

It is unlawful for any person to throw or place, or allow to be thrown or placed, in any river, stream, or watercourse, any cinders, ashes, bricks, stone, rubbish, dust, filth, or other matter likely to cause annoyance. This Act does not apply to London.

L.G.A.

Makes the C.C. the S.A. for the purposes of the R.P.P.A., with regard to any stream which is within or passes through or by their county.

SCOTLAND.

Acts Concerned.

R.P.P.A., 1876, 1893 ; P.H.(S.)A., 1897.

Provisions.—R.P.P.A. as above, while those of the P.H.(S.)A. will be found on pp. 603, 606.

IRELAND.

Acts Concerned.

R.P.P.A., 1876, 1893 ; D.(A.)A., 1894 ; P.H.A.A.A., 1890, Part III. (adoptive).

Provisions.—They apply as above.

Alkali, Chemical, and other Works.

Acts Concerned.

A.W.R.A., 1881 ; A.W.R.A.A.A., 1892.

Application.—Great Britain and Ireland.

Provisions.—The works included are alkali works, which are defined as "works for the manufacture of alkali, sulphate of soda, or sulphate of potash, in which muriatic gas is evolved ; and for the purpose of this definition, the formation of any sulphate in the treatment of copper ores by common salt or other chlorides will be deemed to be a manufacture of sulphate of soda." In addition to alkali works, the other works included are sulphuric acid works, chemical manure works, gas-liquor works, nitric acid works, sulphate of ammonia works, muriate of ammonia works, chlorine and bleaching powder works, venetian-red works, lead deposit works, arsenic works, nitrate and chloride of iron works, muriatic acid works, fibre separation works, tar and zinc works; also the following, unless the process adopted be such that no sulphuretted hydrogen is evolved, alkali waste works, barium works, strontium works, antimony sulphide works, and bisulphide of carbon works. All these must be registered with the L.G.B., as must any work for the extraction of salt from brine and any cement work. The L.G.B. supervises all these works by means of inspectors.

The Acts require the condensation of gases evolved from alkali works. As regards hydrochloric acid gas, 95 per cent. of the amount evolved must be condensed, and not more than $\frac{1}{5}$ gr. of hydrochloric acid gas per cubic ft. of air, smoke, or chimney gas must escape from the works into the atmosphere. As regards acid gases of sulphur and nitrogen, not more than the equivalent of 4 grs. of sulphuric anhydride per cubic ft. of air must escape from the works. Heavy penalties are provided for contravention of these provisions. In addition, the owner must use the best practicable means of preventing all noxious and offensive gases being discharged into the atmosphere, and for rendering them harmless and inoffensive.

Acid drainage and alkali waste must be kept apart, so as to avoid nuisance from the admixture. Penalties are provided, and a daily continuing penalty. The owner may require the S.A. to provide and maintain, at his expense, a drain for carrying the acid waste to the sea, or to any watercourse in which it can be discharged without breach of the R.P.P.A.

Alkali waste must not be deposited or discharged unless the best practicable means are taken to prevent nuisance. The inspector may serve notices requiring the abatement of such nuisance, and penalties are provided.

Acid gases of sulphur and hydrogen evolved from sulphuric acid works must be so condensed, that the total acidity of such gases in each cubic ft. of air, smoke, or gases escaping into the atmosphere does not exceed the equivalent of 4 grs. of sulphuric anhydride; and in these works also the best practicable means must be taken to prevent noxious effluvia. In calculating the proportion of acid to a cubic ft. of air, smoke, or gases, the volume of these latter must be taken at a temperature of 60° F. and a barometric pressure of 30 in.

Scotland.—The Secretary for Scotland, and not the L.G.B., controls the inspectors.

Ireland.—The English L.G.B. appoints the inspectors. Otherwise, the Irish L.G.B. is the central authority.

Coal Mines.

Acts Concerned.

C.M.R.A., 1887; R.P.P.A., 1876, 1893 (p. 563).

Application.—The C.M.R.A. applies to Great Britain and Ireland.

Provisions.—The C.M.R.A. deals with mines of coal, stratified ironstone, shale, and fireclay.

Part I.

No boy under 12 years of age and no female may be employed in any mine under ground. The Act limits the underground working hours per day and per week of males between 12 and 16. It also regulates the hours of "above-ground" work of boys, women, and girls per day and per week. It further prescribes intervals for rest and meals, and prohibits certain heavy work. A register is to be kept of all boys working below ground, and of all boys, women, and girls working above ground. It is the duty of the mine manager to keep this register, and no boy may be employed below ground without his knowledge. As regards safety of the workers and ventilation, single shafts are prohibited, and there must be at least two shafts, not less than 15 yds. apart. The communication between shafts and outlets must be 4 ft. wide, and of a similar height. Each shaft must be provided with proper apparatus for raising and lowering persons, and a plan of the mine must be kept at the office.

Notice of any accident must be given to the inspector of the district, and any abandoned mine must have its shafts and entrances fenced.

Any shaft or side entrance not fenced and within 50 yds. of any highway, road, footpath, or place of public resort, or which is in open or unenclosed land, is declared to be a nuisance under s. 91, P.H.A., 1875.

The inspector has power to inquire into the ventilation of the mine, and the ages and safety of all employees in the mine, and to order the remedy of any condition tending to injury of the workers.

PART II.—RULES; GENERAL AND COMPULSORY.

1. Adequate ventilation is required throughout the mine.
2. Return air, if inflammable, is to be carried clear of any fire used for ventilation by a "dumb drift" or airway.
3. Ventilation apparatus is to be placed out of reach of injury by explosion.
4. The mine must be inspected as to ventilation and general safety before each shift.
5. Entrances, old shafts, and machinery have to be fenced.
6. Safety lamps are to be used whenever the least risk exists, and miners are not to carry matches or to be provided with keys for the lamps.
7. Explosives are not to be stored in the mine.

A *ventilating district* is defined as the part of a seam with an independent intake from the main intake and a return airway.

Special rules may be enacted for each mine.

S. 38, P.H.A., 1875, *i.e.* relating to privy accommodation for any house used as a factory or building in which both sexes are employed, shall apply to those portions of the mine above ground where women and girls are employed.

Quarries.

ACT CONCERNED.

Q.F.A., 1887.

APPLICATION.—England and Wales.

PROVISIONS.—A dangerous quarry, within 50 yds. of the public highway or in any open place, must be kept reasonably fenced for the prevention of accidents, or it is declared to be a nuisance under s. 91, P.H.A., 1875.

Barbed Wire.

ACT CONCERNED.

B.W.A., 1893.

PROVISIONS.—Barbed wire which is a nuisance to a highway means barbed wire which may probably be injurious to persons or animals lawfully using such highway, and may be dealt with under s. 91, P.H.A., 1875.

Factories and Workshops, including Bakehouses.

ACT CONCERNED.

F.&W.A., 1901.

APPLICATION.—United Kingdom and Ireland. The Act came into operation on January 1, 1902.

PROVISIONS.—This important Act repeals the F.&W.As. of 1878 and 1883, and most of the sections of the F.&W.As., 1891 and 1895. The remaining sections of these latter Acts are also repealed by this Act after a date to be fixed by the Home Secretary. The F.&W.A., 1901, also repeals the Cotton Cloth Factories Acts of 1889 and 1897.

The Act is divided into ten parts.

DEFINITIONS.—A *factory* is defined as a textile and non-textile factory, or either of these descriptions of factories.

A *textile factory* means any premises wherein, or within the close or curtilage of which, steam, water, or other mechanical power is used in any process incident to the manufacture of cotton, wool, hair, silk, flax, etc., or any fabric made thereof. The term excludes print works, bleaching and dyeing works, lace warehouses, paper mills, flax scutch mills, rope and hat works.

A *non-textile factory* means any premises wherein manual labour as well as mechanical power is used for the manufacture, repair, alteration, or adaptation for sale of any article. The term includes print works, bleaching and dyeing works, paper mills, and flax scutch mills; and, in addition, earthenware works, lucifer-match works, percussion cap and cartridge works, paper-staining works, fustian-cutting works, blast furnaces, copper and iron mills, foundries, metal and indiarubber works, glass works, tobacco factories, printing, bookbinding, electrical stations. Also bakehouses, shipbuilding yards, quarries and pit banks, dry cleaning, carpet beating, and bottle washing works, lace warehouses, and rope and hat works where mechanical power is used.

A *tenement factory* is a factory where mechanical power is supplied to different parts of the same building occupied by different persons for any manufacturing process or handicraft. All buildings situated within the same close or curtilage shall be treated as one building.

The expression *workshop* means any premises belonging to those trades mentioned above in the last paragraph of the definition of non-textile factories if mechanical power be not used in them. It also includes any premises in which manual labour is employed for the purposes of manufacturing, repairing, altering, ornamenting, finishing, or adapting for sale any article, and to or over which premises the employer of persons working therein has the right of access or control. The term also extends to a *tenement workshop*, *i.e.* any workplace in which, with the permission of, or under agreement with, the owner or occupier, two or more persons carry on any work which would constitute the workplace a workshop if the persons working therein were in the employment of the owner or occupier.

It is apparent from these definitions that the essential difference between a factory and a workshop is that in the former mechanical power is used, while it is not employed in the latter.

Part I. of the Act deals with Health, Safety, and Accidents.

1. *Health.*—Every factory, except a domestic factory (p. 574), must be kept in a cleanly state, free from effluvia arising from any drain, water-closet, earth-closet, privy, urinal, or other nuisance, must not be so overcrowded during work hours as to be injurious or dangerous to health, and must be so ventilated as to render harmless, as far as practicable, all gases, vapours, dust, or other impurities generated therein that may be injurious to health. The part of s. 91, P.H.A., 1875, which deals with similar matters does not now apply to any factory to which this section applies. Inside walls, ceilings, passages, and staircases of a factory must be limewashed at least once every fourteen months, and painted or varnished surfaces must be washed with hot water and soap with the same frequency. The Secretary of State may, by Special Order, grant special exceptions to the requirements as to limewashing and washing. Contravention of any part of this section renders the occupier liable to a fine, and he may be compelled to adopt means whereby the state of the factory will be made conformable with this Act.

Every workshop and workplace, and such factories as are not governed by the preceding section, must be kept clean, well ventilated, and not overcrowded, as provided by s. 91 of the P.H.A. Every workshop and workplace must be kept free from effluvia arising from any drain, water-closet, earth-closet, privy, urinal, or other nuisance; otherwise, it is deemed to be a nuisance, and is liable to be dealt with under the P.H.A.

On the certificate of a M.O.H. or an I.N. that the limewashing, cleansing, or purifying of any workshop is necessary for the health of the persons employed therein, a D.C. must give written notice to the owner or occupier to do what is necessary, and if he fail to comply within a specified time, he is liable to a daily penalty during default, and the D.C. may do the work themselves, and recover the cost in a summary manner. These provisions do not apply to workshops or workplaces governed by the P.H.(London)A., 1891.

A factory or workshop is so overcrowded as to be dangerous or injurious to the health of the employees, if less than 250 cubic ft. of space, or during overtime less than 400 cubic ft. of space, is provided for each person employed in any room. The Secretary of State may, by Special Order, increase these amounts for any particular manufacture, or when artificial light other than electric light is employed, or when the workshop or workplace, not being a domestic workshop, is occupied by day as a workshop, and by night as a sleeping apartment. This power has now been exercised with regard to the last named, 400 cubic ft. being required.

A notice must be affixed in every factory and workshop specifying the number of persons who may be employed in each room.

If the D.C. fail to carry out these provisions, the Secretary of State may entrust such duties to an inspector, who may enforce them with respect to workshops and workplaces as well as to factories. A factory inspector cognisant of defects in any factory or workshop, punishable or remediable under the P.H.A., must notify the same to the D.C., and the D.C. must take proceedings within one month, otherwise the power to do so is conferred upon the inspector.

For the purposes of this section, an inspector may take with him into a factory or workshop a M.O.H., or an I.N., or other officer of the D.C.

In every factory and workshop a reasonable temperature must be secured and maintained in each working-room, but the purity of the air must not be endangered. The Secretary of State may, by Special Order, direct thermometers to be provided, maintained, and kept in working order in certain factories and workshops.

Means of ventilation must be provided, proper ventilation maintained in every room, and standards of ventilation may be prescribed by the Secretary of State. Failure in this respect renders a workshop liable to be dealt with as a nuisance.

Where possible, wet must be drained off from floors.

Sufficient and suitable sanitary conveniences must be provided in every factory and workshop, and separate accommodation for persons of each sex. The proportion of conveniences to the employees may be fixed by Special Order of the Secretary of State. This section does not apply to London nor any place which has adopted s. 22, P.H.A.A.A., 1890 (p. 491).

As regards cleanliness, ventilation, overcrowding, and drainage of floors, a workshop in an insanitary condition is dealt with as a nuisance under the P.H.A., while a factory in a similar state is dealt with under this Act.

2. *Safety.*—Various provisions are set forth to secure the safety of workers against dangers from machinery, steam boilers, fire, and dangerous trades. Means of escape from fire must be provided in all factories and workshops employing more than forty people, and the D.C. may make by-laws with regard to these, and must inspect and ascertain if such means are provided, and compel the owner, if in default, to provide them.

3. *Accidents.*—This section is not concerned with public health.

Part II. deals with Employment.

Definitions.—The expression *woman* means a woman of the age of 18 years and upwards. A *young person* means a person who has ceased to be a child, and is under the age of 18 years. A *child* means a person who is under the age of 14, and who has not, being of the age of 13 years, obtained the certificate of proficiency or attendance at school mentioned in Part III. of this Act.

In textile factories, women and young persons must not be employed longer than twelve hours a day, five days a week, and on Saturdays not longer than six hours, confined to the morning. Time is to be allowed for meals during the hours of employment, and work must not continue longer than four and a half hours at a stretch without at least half an hour for a meal. Children must not be employed for more than half days, unless employed only on alternate days. The same provisions as above apply to their meal-times. They must not be employed on two successive Saturdays, nor on any Saturday if on any other day in the same week their period of employment has exceeded five and a half hours.

In non-textile factories and workshops, women and young persons must not be employed for longer than twelve hours on five days a week, nor eight hours on Saturdays. Regular times are to be allowed for meals, and no woman or young person in a non-textile factory may be employed continuously longer than five hours without at least half an hour for meals. The same period applies to the employment of any young person in a workshop. Children are not to be employed for more than half days, unless on alternate days only, and must not be employed on Saturday afternoons, nor for more than five hours without at least half an hour for meals.

Print works, bleaching and dye works, are to be governed by the same regulations as textile factories with regard to the hours of employment. There are special provisions as to employment in women's workshops. Employment either within or without the factory or workshop is to be counted as part of the hours of employment. The occupier of every factory and workshop must specify in a notice the periods of employment, meal-times, and the conditions of employment of children. Meal-times for women, young persons, and children must be simultaneous. Their employment during meal-times is forbidden, and they are not allowed to remain at such times in any room in which work is going on. There is a prohibition on the employment of a woman, young person, or child on Sunday in a factory or workshop. Holidays are prescribed. The employment of male young persons above the age of 16 in lace factories and bakehouses is governed by special and very similar rules.

Overtime.—In the case of non-textile factories, workshops, and warehouses, a woman must not be employed overtime more than three days in the week, or thirty days in the year. If the goods be perishable, the latter term is extended to fifty days in the year. Different regulations as to overtime are specified for various factories, such as those driven by water power and liable to be stopped by drought or floods, turkey-red dyeing, etc. Overtime for women is not permitted in any textile factory, except in such part of it in which persons are solely employed in polishing, cleaning, wrapping, or packing up goods, and which is not used for any manufacturing process or handicraft. It is permitted in non-textile factories and workshops—(*a*) where the material is liable to be spoiled by weather; (*b*) where there is recurring press of work at definite seasons; (*c*) where the business is liable to sudden, unforeseen press of work; (*d*) in any part of these used as a warehouse.

Night work.—A male young person above 14 years of age may be employed at night in blast furnaces, iron mills, letterpress-printing works, and papermills, but not more than seven nights in any two weeks, and under certain restrictions. In other non-textile factories and workshops, night work is only permitted in the case of male young persons of 16 years of age and upwards, and then only by special permission of the Secretary of State. Special provisions apply to glass works and newspaper printing as regards the employment of male young persons above 14 and 16 years of age respectively.

Supplemental.—The Secretary of State has power to impose, by Order, special sanitary requirements as to the cleanliness, ventilation, and period of employment to be observed in any factory or workshop where women, young persons, or children are employed overtime or at night. The occupier of a factory or workshop must inform the inspector, affix a notice, and make an entry in his register, concerning the employment of such persons overtime or at night.

Fitness for employment.—An occupier may not knowingly employ any woman or girl in any factory or workshop within four weeks after she has given birth to a child. A child under the age of 12 years must not be employed in a factory or workshop unless lawfully so employed at the commencement of this Act. A young person under the age of 16, or a child, must not be employed in a factory without a certificate of fitness for employment from the certifying surgeon of the district. An occupier of a workshop may obtain a similar certificate as to young persons and children in his employment. The Secretary of State may apply the factory prohibition to any workshop. An inspector may at any time require a surgical certificate as to the capacity for work of any young person under 16, or of any child, employed in any factory or workshop.

Part III.

This contains regulations as to the education of children employed in factories and workshops.

Part IV.—Dangerous and Unhealthy Industries.

1. *Special provisions.*—Every medical practitioner attending or called in to visit a patient whom he believes to be suffering from lead, phosphorus, arsenical, or mercurial poisoning, or anthrax, contracted in any factory or workshop, must (unless the notice required by this subsection has been previously sent) send to the chief inspector of factories at the Home Office, London, a notice stating the name and full postal address of the patient and the disease from which the patient is suffering, and is entitled to a fee of two shillings and sixpence for each such notice. Failure to send such notice forthwith renders him liable to a penalty not exceeding 40s. The same provisions may be applied to any other disease by the Secretary of State.

Where dust, gas, vapour, or other impurity is generated and inhaled by the workers to an injurious extent, an inspector may direct that a fan or other mechanical means of ventilation be provided.

Lavatories must be provided, and meals taken in a separate room, in every factory or workshop where lead, arsenic, or other poisonous substance is used. A woman, young person, or child must not be employed in wet spinning unless means are taken for protection from wetting, and for the prevention of the escape of steam into the workroom. A young person or child must not be employed in silvering mirrors with mercury, or in making white lead. A female young person or child must not be employed in melting or annealing glass. A girl under 16 years must not be employed in making or finishing bricks or non-ornamental tiles, or the making or finishing of salt. A child must not be employed in any dry grinding in the metal trade, or in the dipping of lucifer matches.

A woman, young person, or child must not take a meal or remain during meal-times in the mixing rooms of glass works, the grinding, cutting, or polishing rooms of flint-glass works, in any part of a lucifer-match works except the wood-cutting room, or in the dippers' house, dippers' drying-room, or china scouring-room of earthenware works. This prohibition may also be extended by the Secretary of State to other factories or workshops in which the taking of meals therein is specially injurious to health.

2. *Regulations for dangerous trades.*—The Secretary of State may make regulations for persons employed in dangerous trades. He must give notice of the proposed regulations, and consider any objections thereto, and may appoint

a special inquiry to be made. The regulations do not require confirmation by Parliament, but must be laid before Parliament, and may be annulled by either House within forty days. Notice of such regulation must be published in the Gazettes, and copies supplied to occupiers, and conspicuously posted in any factory or workshop concerned.

Application of regulations.—To any factory or workshop, including tenement factories and workshops.

Provisions of regulations.—The regulations may, among other things—(*a*) prohibit the employment of, or modify or limit the period of employment of, all persons, or any class of persons, employed in connection with any manufacture, machinery, plant, process, or description of manual labour certified to be dangerous; (*b*) prohibit, limit, or control the use of any material or process; (*c*) modify or extend any special regulations for any class of factories or workshops contained in this Act.

Part V.—Special Modifications and Extensions.

1. *Tenement factories.*—The owner of these, instead of the occupier, is the person bound to observe the provisions of this Act with regard to cleanliness, freedom from effluvia, overcrowding, and ventilation, limewashing and washing, and the supply of means to prevent the inhalation of dust, gas, vapour, and other impurity.

2. *Cotton-cloth and other humid factories.*—In every room, shed, or workshop, or part thereof, in which the weaving of cotton-cloth is carried on (*cotton-cloth factory*), the amount of moisture in the atmosphere must not at any existing temperature exceed the number of grains of moisture per cubic ft. of air specified in the Table for that temperature (see App. B, p. 624). The temperature must not be artificially raised above 70° F., except by gas used for lighting, or so far as is necessary in the process of giving humidity to the atmosphere. Evidence of the limit of moisture having been passed is obtained by the reading of the wet-bulb thermometer being higher than the figure shown in the table to correspond to the dry-bulb temperature and the allowed moisture. Two sets of standardised wet- and dry-bulb thermometers must be provided, maintained, and kept in correct working order in every cotton-cloth factory. These are to be placed as directed by the inspector, and read thrice daily at specified times by the person in charge of the factory. Each reading must be recorded and exhibited in the workroom, and the record sent monthly to the inspector of the district. Where artificial means are used to produce humidity of the atmosphere, notice must be given by the occupier to the chief inspector of factories, and the factory must be inspected once every three months as to temperature, humidity, ventilation, and fresh air. Water used for producing humidity must be pure or effectively purified, and ducts for the introduction of humidified air must be kept clean. Steam-pipes within a cotton-cloth factory, in which the temperature is 70° F. or over, must be as small and short as practicable, and must be covered with non-conducting material. During working hours the proportion of carbonic acid in the air of any cotton-cloth factory, in which the atmosphere is rendered artificially humid, must not exceed 9 volumes of carbonic acid to every 10,000 volumes of air. The outside of the roof of every cotton-cloth factory must be whitewashed annually in May, and kept so during the summer months. A suitable cloak-room properly ventilated and warmed must be provided.

The above provisions, with certain modifications, apply to every textile factory in which atmospheric humidity is artificially produced.

3. *Bakehouses.*—These must not be let or occupied unless the following regulations are complied with :—

(*a*) A water-closet, earth-closet, privy, or ashpit must not be within or communicate directly with the bakehouse.

(*b*) Every cistern for supplying water to the bakehouse must be separate and distinct from any cistern for supplying water to a water-closet.

(*c*) A drain or pipe for carrying off fæcal or sewage matter must not have an opening within the bakehouse.

On the prosecution of an inspector or a D.C., a court of summary jurisdiction may fine the occupier of an insanitary bakehouse, and may order abatement of the condition. The inside walls, ceilings, passages, and staircases of a bakehouse must either (1) be painted with oil or varnished, the paint or varnish being renewed once every seven years, and the surface washed with hot water and soap every six months, or (2) must be limewashed, the limewashing being renewed once every six months. No place on the same level with a bakehouse and forming part of the same building may be used as a sleeping-place, unless it is effectually separated from the bakehouse by a partition extending from floor to ceiling, and has an external glazed window not less than 9 superficial ft. in area, and of which at least half is made to open. An underground bakehouse shall not be used as a bakehouse unless so used at the passing of this Act ; and, subject to this provision, after January 1, 1894, an underground bakehouse may not be used unless certified as suitable by the D.C. An underground bakehouse is a bakehouse, any baking-room of which has a floor more than 3 ft. below the surface of the adjoining ground.

This provision applies to bakehouses in London, though not included in the P.H.(London)A., 1891. Retail bakehouses are under the control of the D.C. of the district in which they are situate, and not under an inspector of factories, and the M.O.H. of the D.C. possesses all the powers of an inspector. *Retail bakehouse* means any bakehouse or place not being a factory, the bread, biscuits, or confectionery baked in which are sold not wholesale, but by retail in some shop or place occupied with the bakehouse.

4. *Laundries.*—In the case of women and young persons, the period of employment is restricted to sixty hours per week, and of children to thirty hours. Provisions are made for meals, holidays, and working overtime. Laundries are to be regarded as factories or workshops, according as mechanical power is used or not, and the provisions with regard to health, safety, etc., apply as in them.

In the case of every laundry worked by mechanical power—

(*a*) A fan or other means must be provided and used for regulating the temperature in every ironing-room, and for carrying away the steam in every wash-house.

(*b*) All stoves for heating irons must be sufficiently separated from any ironing-room, and gas irons emitting any noxious fumes must not be used.

(*c*) The floors must be kept in good condition and drained.

Certain forms of laundry are excepted from these provisions.

5, 6, and 7. *Docks, buildings, and railways.*—The provisions of the Act as to dangerous trades apply to these.

PART VI.—HOME WORK.

(*a*) In certain trades lists of outworkers must be kept and furnished to the inspector when required, and to the D.C. twice a year.

(*b*) With regard to certain classes of work, the D.C. may, if the place of employment be dangerous or injurious to the health of the workers, give notice to the occupier, and work therein must cease after one month from such notice.

(*c*) The occupier must not allow any wearing apparel to be made, cleaned, or repaired in any dwelling-house or building occupied therewith while any inmate is suffering from scarlet fever or smallpox, and in default is liable to a penalty, unless he prove that he was not aware, and could not reasonably have been expected to become aware, of the existence of such illness. The making, cleaning, washing, altering, ornamenting, finishing, and repairing of wearing apparel, and any other prescribed occupation in any house in which there is infectious disease (as specified in the I.D.N.A.), or in any house which has not been properly disinfected after infectious disease, may be forbidden by order of the D.C. as far as the giving out of the work to any person living or working in such house is concerned.

As regards (*a*), (*b*), and (*c*), the Secretary of State made an Order (December 11, 1901) prescribing the classes of work to which these provisions shall apply.

Thus (*a*) and (*b*) apply to the making, cleaning, washing, altering, ornamenting, finishing, and repairing of wearing apparel, and any work incidental thereto; the making, ornamenting, mending, and finishing of lace and of lace curtains and nets. Also cabinet and furniture making and upholstery work, the making of files and electroplate, and fur-pulling.

(*c*) Applies to the making, cleaning, washing, altering, ornamenting, finishing, and repairing of wearing apparel, and any work incidental thereto; the making, ornamenting, etc., of lace and of lace curtains and nets, upholstery work, and fur-pulling.

A *domestic factory* or *domestic workshop* means a private house, room, or place, which, though used as a dwelling, is, by reason of the work carried on there, a factory or a workshop, and in which mechanical power is not used, and the only persons employed are members of the same family dwelling there.

In domestic factories, the periods of employment allowed are as follows:—A young person may not be employed before 6 a.m. and after 9 p.m., and must receive four and a half hours for rest and meals within these hours. On Saturdays work must cease at 4 p.m., and the period of rest must be two and a half hours. A child may only be employed for half days. Certificates of fitness for employment are required, but the provisions of the Act relating to the sanitary condition of factories does not apply, nor do several other regulations as to factories. If dangerous processes are carried on in domestic factories and workshops, all the provisions of the Act apply. Straw-plaiting, pillow-lace making, and glove making may be exercised in a private house by the family dwelling therein, without constituting the house a domestic workshop. So also with regard to handicrafts exercised at irregular intervals, and not furnishing the principal means of living to the family.

PART VII. DEALS WITH WORK AND WAGES.

PART VIII. DEALS WITH ADMINISTRATION.

The D.C. and their officers have powers of entry, inspection, etc., with regard to workshops and workplaces. A general register must be kept in every factory and workshop in which must be entered the particulars already mentioned. Every D.C. must keep a register of all workshops in their district. The M.O.H. of a D.C. must, in his annual report, report specifically on the administration of this Act in workshops and workplaces, and he must send a copy to the Secretary of State. He must also give written notice to the inspector of the district if he is aware that any woman, young person, or child is employed in a workshop in which no abstract of this Act is affixed as by this Act required.

PART IX. DEALS WITH LEGAL PROCEEDINGS.

PART X.—SUPPLEMENTARY.

The important definitions contained in this part of the Act have already been detailed.

LONDON.

The D.C. referred to in the Act is in London, the Metropolitan Borough Council, and in the City, the Court of Common Council; but in the part of the Act relating to escape fom fire, the L.C.C. is the authority instead of the D.C.

SCOTLAND.

The L.A. is the "District Council" referred to in the Act.

IRELAND.

The Act applies as in England, with minor modifications.

Infant Life Protection.

ACT CONCERNED.

INFANT LIFE PROTECTION ACT, 1897.

APPLICATION.—Great Britain and Ireland.

PROVISIONS.—Any person retaining or receiving for hire or reward more than one infant under the age of 5 years for a longer period than forty-eight hours for the purpose of nursing or maintaining such infants, must within forty-eight hours give notice thereof to the L.A.

Such notice must state the name, age, and sex of such infants, the name of the person receiving the infants, the situation of the house, and the name and address of the person or persons from whom the infants have been received. Further, notice must be given of the removal of such infants, and of the name and address of the person to whose care the infant has been transferred. The L.A. must provide for the execution of this Act within its district, and may appoint male or female inspectors to enforce the Act. Periodical inspection must be made both of infants and premises. If refused admittance, the inspector may obtain a warrant. The L.A. must fix the number of infants under 5 years of age which may be retained or received in any such dwelling. Any person taking an infant under the age of 2 years, and receiving a lump sum of not more than £20 for permanent charge, must notify the L.A. of the fact within forty-eight hours. The L.A. must give public notice of the provisions of the Act. If any infant be kept in any house or premises which are so unfit or so overcrowded as to endanger its health, or be retained or received by any person who, by reason of negligence, ignorance, or other cause, is so unfit to have its care and maintenance as to endanger its health, the L.A. may grant an order to an inspector directing him to remove such infant to a workhouse or place of safety. The person from whom the infant was so removed may not keep an infant for hire or reward without the written sanction of the L.A.

An inquest must be held in the case of the death of an infant respecting whom notice must be given under this Act, unless there is a satisfactory medical certificate as to the cause of death.

Offences under this Act are punished by fine or imprisonment.

Diseased Animals.

Acts Concerned.

Diseases of Animals Acts, 1894, 1896; Contagious Diseases (Animals) Act, 1878, s. 34 only; Contagious Diseases (Animals) Act, 1886, s. 9 only. In addition, Orders of the Board of Agriculture.

Application.—Great Britain and Ireland.

Provisions.—The unrepealed sections of the C.D.(A.)A., 1878 and 1886, refer to dairies, cow-sheds, and milk-shops, and have been given on p. 546.

D.(A.)A., 1894, 1896.

The diseases dealt with are cattle-plague (rinderpest), pleuro-pneumonia, foot-and-mouth disease, sheep-pox, sheep-scab, and swine fever; in addition, other diseases specified in Orders of the B. of A. Among the latter are glanders including farcy, rabies, anthrax, sarcoptic mange, parasitic mange, influenza (pink-eye), strangles. The last four only apply to horses, asses, and mules, and the Orders are only local in their application. Orders relating to the other diseases apply to the whole country.

The Act provides for compulsory notification, isolation, disinfection of persons, animals, articles, and premises, the prohibition of movement of animals in, into, or out of the infected place, slaughter (in some cases) of infected animals, and of those suspected of being infected, destruction of fodder, litter, dung, and other things likely to be infected. The B. of A. must cause to be slaughtered all animals affected with cattle-plague, and all animals which have been exposed to infection from such animals, all cattle affected with pleuro-pneumonia, and all cattle "coming foreign" from certain specified countries.

Foreign cattle are landed at special wharves, and there slaughtered within ten days of arrival. Exception is made in the case of animals intended for exhibition and other exceptional purposes, such as breeding. The landing of certain animals is absolutely prohibited.

The B. of A. may order to be slaughtered any animals suffering from foot-and-mouth disease, suspected of the disease, or exposed to infection by the disease. Also any swine affected with, suspected of, or exposed to swine fever.

The same provision may be applied by the Board to any other disease. The L.A. must slaughter all sheep affected with sheep-pox within two days, and every dog suffering from rabies, suspected to be so, or which has been bitten by a rabid or suspected dog.

The L.A. may slaughter other animals suffering from rabies or suspected to be so; also any cattle, sheep, or swine affected with, suspected of, or exposed to foot-and-mouth disease, and any horse, ass, or mule affected with, or suspected of glanders or farcy.

The L.A. must slaughter any animal affected with, suspected of, or exposed to anthrax, and care must be taken to avoid, as far as possible, effusion of the blood.

Sheep-scab must be treated by the person in charge of the sheep, and the L.A. may make regulations for disinfection, cleansing, dipping, etc. Compensation, where legal, may be paid by the B. of A. out of the taxes, and by the L.A. out of the rates. The Board may reserve for observation and treatment an animal liable to be slaughtered under the Act.

The carcase of a slaughtered animal belongs to the "executing" authority, and directions are set forth as to its disposal.

Offences against the Act are punished by fine or imprisonment.

Definitions and Special Applications.—*Cattle* includes bulls, cows, oxen, heifers, and calves. *Animal* means cattle, sheep, and goats, all other ruminants and swine.

The Glanders and Farcy Order (1894) applies to horses, asses, and mules.

The Anthrax Order (1895) applies to horses, asses, and mules, besides those animals included in the above definition of animal.

The Rabies Order (1897) applies to horses, asses, mules, and dogs.

Vaccination.

Acts Concerned.

Vaccination Acts, 1867, 1871, 1874, 1898; L.G.B. Act, 1871.
In addition, Special Orders of L.G.B.

The first Vaccination Act was passed in 1840, amended in 1841, and provided free optional vaccination for every person in England, Wales, and Ireland. It prohibited inoculation of smallpox. Vaccination was made compulsory by the Act of 1853, and in Scotland by that of 1855. These Acts were wholly repealed by the Act of 1867, which to some extent is still in force, and with the later Acts really constitutes one Vaccination Act.

Provisions.—The Act requires the establishment of vaccination districts by the Poor-Law Guardians, for each of which a medical practitioner is appointed as public vaccinator. The L.G.B. has power under the L.G.B. Act, 1871, to prescribe the qualifications of public vaccinators, to make regulations as to vaccination, and as to the expenditure of money granted by Parliament for vaccination. A public vaccinator is paid for successful vaccinations and revaccinations within his own district, or in special circumstances outside his own district. The parent or person having the custody of a child must have it vaccinated within six months of birth, but it is not compulsory to have vaccination performed by a public vaccinator. The public vaccinator of the district must, if the parent or custodian so require, visit the home of the child for the purpose of vaccinating the child; in other words, this gives the option of domiciliary vaccination in place of that at a vaccination station. If a child is not vaccinated within four months after its birth, the public vaccinator of the district must, after twenty-four hours' notice to the parent or custodian, visit the home of the child and offer to vaccinate the child with glycerinated calf lymph, or such other lymph as may be issued by the L.G.B. The public vaccinator must not vaccinate a child if, in his opinion, it cannot be safely vaccinated owing to the condition of the house in which it resides, or to a recent prevalence of infectious disease in the district. On these grounds he may postpone vaccination, and must give notice of his having done so to the M.O.H. of his district. The parent of any child born in any institution may not be compelled by any regulation of such institution to allow a child to be vaccinated at an earlier period than that provided by the Act. Vaccination of any child is not compulsory if the parent or custodian, within four months from its birth, satisfies two justices, a stipendiary, or metropolitan police magistrate in petty sessions, that he conscientiously believes that vaccination would be prejudicial to the health of the child, obtains a certificate to that effect, and delivers it within seven days to the vaccination officer of his district. The vaccination officer is an official appointed by the Board of Guardians under the 1871 Act to receive the certificates and execute the Acts. The public vaccinator must call between the sixth and fourteenth days to inspect the arm in the case of domiciliary vaccination. There are three certificates which may be given on prescribed forms for—(*a*) Successful vaccination. There is no legal definition of successful vaccination. The public vaccinator must aim at producing four separate, good-sized vesicles or groups of vesicles, not less than $\frac{1}{2}$ in. from one another. (*b*) Postponement of vaccination for a period not exceeding two months. The postponement may be extended for similar periods, a fresh certificate being required each time. (*c*) Insusceptibility to vaccination. There is no law as to what constitutes insusceptibility, but it is not usual to grant such a certificate unless the attempt has been made three times to vaccinate the child and always without success.

The L.G.B. may, by Order, in case of serious risk of outbreak of smallpox, or in other exceptional circumstances, require the Guardians of any Poor-Law Union to provide vaccination stations for the vaccination of children; and with regard to the area to which the Order applies, and during the period for which it is in force, may modify the provisions of the Act requiring the public vaccinator to visit the home of the child otherwise than on request of the parent. The clerk of any S.A. which maintains a smallpox hospital, must keep a list of the names, addresses, ages, and condition as to vaccination of all smallpox patients treated in the hospital. Penalties in the shape of fine and imprisonment are imposed for non-compliance with the Act, but no proceedings may be taken on account of the same child after one conviction until the child has reached the age of 4 years. A justice may make an order for the vaccination of an unvaccinated child under 14 years of age, but after conviction of any person for non-compliance with such an order, no similar order may be made relating to the same child. Persons committed to prison under this Act are treated as first-class misdemeanants.

The prohibition against inoculation with smallpox is still in force. Private practitioners performing successful vaccination must give the prescribed certificate, and may sign the other forms of certificate.

In *Scotland and Ireland* vaccination is compulsory, the provisions relating to conscientious objection (1898 Act) not applying.

In Scotland, vaccination must be performed within six months, and in Ireland within three months, after the birth of the child. In Scotland, vaccination administration is entrusted to the P.C. under the supervision of the L.G.B., and the latter may undertake the duties of any defaulting P.C. The P.C. must appoint a public vaccinator, and report his appointment to the L.G.B. within forty-eight hours. The obligation to have vaccination performed on a child rests upon (*a*) the father, (*b*) the mother, (*c*) the custodian of the child; and the certificate of successful vaccination must be transmitted to the registrar within three days after it has been obtained from the vaccinator.

If the certificate is not so delivered to the registrar, he must notify the person responsible, and if there is no response within ten days after the notice, the person is liable to a fine of 20s. and of 1s. to the registrar, or to ten days' imprisonment. The registrar must send to the Inspector of Poor every six months a list of those who have failed to lodge with him the vaccination certificate, and any person who refuses to allow vaccination to be performed is liable to a penalty of 20s. or ten days' imprisonment. The public vaccinator must keep a record of vaccinations performed by him, must send to the registrar within forty-eight hours the contents of any vaccination certificate signed by him, and must make an annual return to the L.G.B. of postponed vaccinations and of cases of insusceptibility to vaccination.

Re-vaccination.—This is not compulsory, but re-vaccination may be performed by a public vaccinator for any person who has reached 15 years of age, or 12 years at a time of epidemic smallpox. The L.G.B. recommends that all persons who have been vaccinated in infancy should, as they approach adult life, undergo re-vaccination.

In Scotland, under s. 77 P.H.(S.)A., 1897, the L.A. may defray the cost of vaccinating or re-vaccinating such persons as to them may seem expedient.

SCOTLAND—SANITARY ACTS.

Those Acts which apply to Scotland, as to the rest of the country, have already been considered. The Public Health (Scotland) Act, 1897, being the latest Public Health Act, is here given separately along with other Scotch Acts which it has not repealed, of which the most important is the Burgh Police (Scotland) Act, 1892.

P.H.(S.)A., 1897.

Definitions.—*Ashpit* means any receptacle for the deposit of ashes or refuse matter.

Author of a nuisance means the person through whose act or default the nuisance is caused, exists, or is continued, whether he be the owner or occupier, or both.

Burgh includes not only royal burgh, parliamentary burgh, burgh incorporated by Act of Parliament, but also any police burgh within the meaning of the Burgh Police (Scotland) Act, 1892.

Burial includes cremation.

Cattle means bulls, cows, oxen, heifers, and calves, and includes sheep, goats, and swine.

Common lodging-house means a house, or part thereof, where lodgers are housed at an amount not exceeding fourpence per night, or such other sum as shall be fixed under the provisions of this Act, for each person, whether the same be payable nightly or weekly, or for any period not longer than a fortnight, and shall include any place where emigrants are lodged, and all boarding-houses for seamen, irrespective of the rate charged for lodging or boarding.

Dairy includes any farm, farmhouse, cow-shed, milk-store, milk-shop, or other place from which milk is supplied, or in which milk is kept for purposes of sale.

Dairyman includes any cowkeeper, purveyor of milk, or occupier of a dairy.

Day and *daytime* mean between 9 a.m. and 6 p.m.

Factory includes workshop and workplace.

House means a dwelling-house, and includes schools, also factories and other buildings in which persons are employed.

Keeper of a common lodging-house includes any person having or acting in the care and management of a common lodging-house.

Knacker means a person whose business it is to kill any horse, ass, mule, or cattle, not killed for the purpose of the flesh being used as butcher's meat; and *knacker's yard* means any building or place used for the purpose of such business.

Land includes water and any right or servitude to or over land or water.

Occupier means in the case of a building, or part of a building, the person in occupation, or having the charge, management, or control thereof, either on his own account or as the agent of another person; and in the case of a ship, means the master or other person in charge thereof.

Owner means the person for the time entitled to receive, or who would, if the same were let, be entitled to receive, the rents of the premises, and includes a trustee, factor, tutor, or curator, and in case of public or municipal property, applies to the persons to whom the management thereof is entrusted.

Premises includes lands, buildings, vehicles, tents, vans, structures of any kind, streams, lakes, seashore, drains, ditches, or places open, covered, or enclosed, whether built on or not, and whether public or private, and whether natural or artificial, and whether maintained or not under statutory authority, and any ship lying in any sea, river, harbour, or other water, or ex adverso of any place within the limits of the local authority.

Ship includes any sailing or steam ship, vessel, or boat not belonging to His Majesty or any foreign government.

Slaughterer of cattle or horses means a person whose business it is to kill any description of cattle or horses, asses, or mules for the purpose of the flesh being used as butcher's meat; and *slaughter-house* means any building or place used for the purpose of such business.

Street includes any highway and any public bridge, and any road, lane, footway, square, court, or passage, whether a thoroughfare or not, and whether or not there are houses in such street.

Explanations.—*Nuisance* is not defined in this Act, but means a "nuisance at common law." In the provisions dealing with nuisances under this Act, both "intimations" and "notices" are mentioned, and the distinction between these must be carefully noted. The L.A. may, by regulation, assign to one of their officers, usually the S.I., the duty of sending intimations on his own initiative; but where a notice is to be served, the L.A. must itself, in meeting, authorise such issue.

Part I. Deals with Administration (see p. 475).

Part II.—SANITARY PROVISIONS.

General Nuisances.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892; H.W.C.A., 1885; C.M.R.A., 1887; Q.F.A., 1887; B.W.A., 1893. In addition, Model Bylaws (p. 558).

P.H.(S.)A., 1897.

Provisions.—S. 16.—The Statutory Nuisances enumerated in the Act are :—

1. Any premises, or part thereof, of such a construction or in such a state as to be a nuisance, or injurious or dangerous to health.

2. Any street, pool, ditch, gutter, watercourse, sink, cistern, water-closet, earth-closet, privy, urinal, cesspool, drain, dung-pit, or ashpit, so foul, or in such a state or so situated as to be a nuisance, or injurious or dangerous to health.

3. Any well or water supply injurious or dangerous to health.

4. Any stable, byre, or other building in which any animal or animals are kept in such a manner or in such numbers as to be a nuisance, or injurious or dangerous to health.

5. Any accumulation or deposit, including any deposit of mineral refuse, which is a nuisance, or injurious or dangerous to health; or any deposit of offensive matter, refuse, or offal, or manure (other than farmyard manure, or manure from byres or stables, or spent hops from breweries), within 50 yds. from any public road wherever situated; or any offensive matter, refuse, or offal, or manure other than aforesaid, contained in uncovered trucks or waggons standing or being at any station or siding or elsewhere on a railway, or in canal boats, so as to be a nuisance, or injurious or dangerous to health.

6. Any work, manufactory, trade, or business injurious to the health of the neighbourhood, or so conducted as to be injurious or dangerous to health, or any collection of rags or bones injurious or dangerous to health.

7. Any house, or part of a house, so overcrowded as to be injurious or dangerous to the health of the inmates.

8. Any schoolhouse, or any factory which is not a factory subject to the provisions of the F.&W.A., 1901, with respect to cleanliness, ventilation, or overcrowding, and which—(1) is not kept in a cleanly state and free from effluvia arising from any drain, privy, water-closet, earth-closet, urinal, or other nuisance; or (2) is not ventilated in such a manner as to render harmless, so far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein that are a nuisance, or injurious or dangerous to health; or (3) is so overcrowded while work is carried on as to be injurious or dangerous to the health of those therein employed.

9. Any fireplace or furnace situated within the limits of any burgh or special scavenging district which does not, so far as practicable, consume the smoke arising from the combustible matter used therein for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever.

10. Any chimney (not being the chimney of a private dwelling-house) sending forth smoke in such quantity as to be a nuisance, or injurious or dangerous to health.

11. Any churchyard, cemetery, or place of sepulture so situated, or so crowded, or otherwise so conducted, as to be offensive or injurious or dangerous to health.

All these nuisances may be dealt with summarily, provided that—(*a*) a penalty shall not be imposed on any person in respect of any accumulation or deposit necessary for the effectual carrying on of any business, trade, or manufacture, if it be proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business, trade, or manufacture, and that the best available means have been taken for preventing injury or damage thereby to the public health; and (*b*) in considering whether any dwelling-house, or part thereof, which is also used as a factory, or whether any factory, used also as a dwelling-house, is a nuisance by reason of overcrowding, the court shall have regard to the circumstances of such other use. It is to be noted that under subsection 9 it is not necessary to aver that there is either nuisance or injury or danger to health, and that under subsection 11 it is sufficient to prove offensiveness. S. 76 of this Act provides that if there be two convictions relating to the overcrowding of any house, the sheriff may direct the closing of such premises for such time as he may deem necessary.

S. 17.—The L.A. must, from time to time, cause their district to be inspected, in order to detect removable nuisances, take action for their removal, and secure the proper sanitary condition of all premises within their district.

S. 18.—On reasonable ground for suspicion on the part of the L.A., M.O.H., or S.I., as to the existence of a nuisance on any premises, they, or any other person authorised by the L.A., may enter and inspect any premises during daytime, or at any hour at which it is suspected that the nuisance is being produced, may open up the ground, test drains, or do any other such work as may be necessary for examination. If admission be refused, a written order for admission may be obtained from the sheriff or any magistrate or justice; and if this be not complied with, a warrant for immediate forcible entry may be obtained. The above order continues in force until the nuisance has been removed and any necessary work done. If no nuisance be found, the L.A. must restore the premises at their own expense.

S. 19.—Any person may, and every officer of the L.A., constable, or police officer of any county or burgh, must, give information to the L.A. concerning any nuisance under this Act.

The L.A. must provide, by regulation, for the immediate intimation of the existence of a nuisance to any person who may be required to remove it. This duty is usually performed by the S.I.

S. 20.—The L.A., if satisfied that a nuisance exists, must serve a notice on the author of the nuisance, or failing him, on the owner or occupier of the premises on which the nuisance arises or continues, requiring him to remove the nuisance within a specified time, and do such works as may be necessary for the purpose, and the L.A. may, if they think it desirable, specify the works which are to be executed by him.

The L.A. possesses powers to prevent recurrence of a nuisance similar to those used to attain its removal.

If the nuisance arise from any want or defect of a structural character, or if the premises are unoccupied, the notice must be served on the owner; and if the person causing the nuisance cannot be found, and neither the owner nor occupier is at fault, the L.A. may themselves remove the nuisance and do any necessary works.

Ss. 21, 22.—On non-compliance with any notice, the L.A. must, or without having served any notice, they apparently may, on being satisfied of the existence of a nuisance or the likelihood of its recurrence, present a petition to the sheriff, or to any magistrate or justice, and he may decree for the removal, remedy, discontinuance, or interdict of the nuisance; and, in addition, may impose a fine if a notice has not been complied with, or if he consider that the nuisance arose from wilful fault or culpable negligence either of the owner or occupier.

In the case of the nuisances mentioned in subsections (6) and (8) of s. 16, such a petition may only be made on a medical certificate (not necessarily that of a M.O.H.), or on a representation of a P.C., or on the written requisition of ten local ratepayers, and may only be made to the sheriff.

In the case of the nuisances mentioned in subsections (9), (10), and (11) of s. 16, petition may only be made to the sheriff; and in regard to the last-named subsection, it is not necessary to cite any person as the author of the nuisance, but the collector of the churchyard or other dues must be informed and may be heard.

S. 23.—If the nuisance proved to exist be such as to render a house or building unfit for human habitation or use, the sheriff, magistrate, or justice may prohibit such habitation or use.

S. 24 provides penalties for contravention of decree and of interdict.

S. 25.—The court may appoint a person to see that any necessary structural works are carried out.

S. 26.—The L.A. may obtain power, on a sheriff's warrant, to do the works on the owner's or occupier's default, or without such warrant may do so when the author of the nuisance cannot be found. The L.A. may recover the cost from the author of the nuisance, or, failing him, from the owner of the premises.

S. 27.—The L.A. may sell any matter or thing removed by them under the provisions of this Act.

S. 28.—The L.A. must replace by a sewer, any watercourse, ditch, gutter, or drain along the side of any street, or between or parallel to rows of dwelling-houses, which is used for the conveyance of any water, sewage, or other liquid, or matter from any premises, and which cannot otherwise be rendered free from foulness or offensive smell. If necessary for outfall or distribution of sewage, such sewer may, with the approval of the L.G.B., be continued by the L.A. outside their own district. The L.A. is not liable to pay damages to any person who has contributed to the nuisance.

S. 29.—The L.A. may erect public ashpits, water-closets, privies, and urinals wherever they think fit, may keep the same in repair, and must cause such privies to be cleansed daily. The L.A. may, by written notice, require the owner or occupier of any schoolhouse, or of any factory or building in which persons are employed in any manufacture, trade, or business, to construct a sufficient number of water-closets or privies for the separate use of each sex.

S. 30.—No person may wilfully destroy, damage, stop up, interfere with, or improperly use any drain, water-closet, earth-closet, privy, urinal, ashpit, or water supply, apparatus, pipe, or work connected therewith, so as to cause it to be a nuisance, or injurious or dangerous to health.

S. 31.—Any water-closet, earth-closet, privy, or similar convenience used in common by the occupiers of two or more similar dwelling-houses—(*a*) must not be injured or improperly fouled, nor must anything used in connection therewith be likewise treated by any person; (*b*) must be kept so clean as not to be a nuisance or annoyance to any of the persons using or entitled to use the same. This applies also to the walls, floors, seats, or fittings of, and the approaches to, such conveniences.

The L.A., or the M.O.H., or the S.I., may decide when such condition amounts to a nuisance or annoyance. Penalties in the shape of fines are provided for contravention of either division of this section.

Ss. 146, 149 (see p. 608).

B.P.(S.)A., 1892.

Application.—The burghs of Scotland, with the exception of Edinburgh, Glasgow, Aberdeen, Dundee, Greenock, and Perth, which possess Local Police Acts.

Provisions.—The Commissioners of Burghs have powers to make by-laws—(*a*) for preventing nuisances and annoyances in any street or any other place within the burgh; (*b*) for regulating the keeping of depôts of bones, carrion, rags, or any other offensive matter or thing; (*c*) for providing that cattle, dogs, and poultry shall not be kept in such places or in such manner as to be a nuisance or annoyance to the inhabitants; for prescribing the situations or places in which swine may be kept, and for prohibiting, on cause shown, the keeping of swine; (*d*) for preventing any ashpit, dungstead, privy, drain, ditch, cesspool, dunghill, or manure heap from being a nuisance or annoyance.

The Act prescribes a penalty in the case of smoke issuing from any furnace or fire, except a household fire, unless the best practicable means are used for preventing it and there has been proper care and management.

This applies to steamers, but not to mines and certain businesses.

The keeping of animals so as to be a nuisance is prohibited under penalty.

Where any room in any common tenement or any building is used for meetings, and is a nuisance, and complaint is made by two or more resident householders, a magistrate may order such use to be discontinued till the nuisance is abated.

Offensive Trades.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892. In addition, Model By-laws, L.G.B. (p. 516).

P.H.(S.)A., 1897.

Provisions.—S. 32.—(1) No person may establish, without the sanction of the L.A., any offensive business, under a penalty of £50; and no person may carry on the same, after a conviction for the establishment thereof, without incurring a penalty of £25 per day. The offensive trades specified are the businesses of blood-boiler, bone-boiler, soap-boiler, tripe-boiler, manure manufacturer, tallow-melter, knacker, tanner, gut or tripe cleaner, skinner or hide factor, slaughterer of cattle or horses, and any other business which the L.A. may declare by order, confirmed by the L.G.B., to be an offensive business. (2) The sanction of the L.A., when granted, must be given by order, after due publicity; and any person aggrieved by the granting or withholding of such sanction may appeal to the L.G.B., or, in the case of districts other than burghs, to the C.C., the decision of which may be appealed against to the L.G.B. by either party. (3) The L.A. may make by-laws—(*a*) regulating the conduct of offensive trades and the removal of refuse in their district, and also the structure of the premises in which any such business is carried on, in order to prevent or diminish the noxious or injurious effect thereof; (*b*) regulating the mode of application for the sanction of the L.A. (4) Such by-laws may, in addition to the imposition of fines, empower the sheriff, by summary order, to deprive any person contravening the by-laws of the right of carrying on the business. The deprivation may be either temporary or permanent. (5) The L.A. may charge any fee not exceeding forty shillings for an order under this section. (6) A business is regarded as being established, not only if it is established newly, but also if it is removed from any one set of premises to any other premises, or if it is renewed on the same set of premises after having been discontinued for a period of twelve months or upwards, or if any premises on which it is for the time being carried on are enlarged without the sanction of the L.A. A business is not deemed to be established anew on any premises by reason only that the ownership or occupancy of such premises is wholly or partially changed, or that the building in which it is established, having been wholly or partially pulled down or burnt down, has been reconstructed without any extension of its area.

S. 33.—(1) Premises must not be used as a slaughter-house or knacker's yard without the person carrying on the business having a licence. The fact that cattle or horses have been taken into unlicensed premises shall be primâ facie evidence that an offence under this section has been committed. Any one establishing the business of slaughterer of cattle or horses, or the business of knacker, requires to obtain, under the previous section, the sanction of the L.A., and also, under this section, a licence from the L.A. to use the premises. (2) The licence is subject to annual renewal on such day as the L.A. fix, and the L.A. may charge a small fee for the licence or any renewal thereof. (3) Opportunity must be given for objections being lodged against either the licence or its renewal, and also (4) for the applicant to repel the objections. (5) A licence of premises may be renewed in favour of another person than the original holder. (6) The L.A. possess the right, and may authorise their officers, to enter any slaughter-house or knacker's yard by day, or at any hour when business is in progress or is usually carried on therein, and examine whether there is any contravention of this Act or by-law made thereunder. (7) If the renewal of a licence be refused, the applicant may appeal to the L.G.B. directly, or in a district other than a burgh to the C.C. in the first instance.

S. 34.—The L.A. of any district other than a burgh may provide, or may combine with any other L.A. to provide, within or without their district, fit shambles or slaughter-houses for the purpose of slaughtering cattle; but such L.A., having done so, appears to possess no power to forbid the use of any other place as a slaughter-house if it be already established as such.

S. 35.—The L.A. may make by-laws regulating the construction of pigstyes, the places in which they may be erected, and the mode of cleansing them at proper intervals, so as to prevent them from becoming a nuisance or dangerous to the public health.

S. 36.—(1) A L.A., upon a certificate by their M.O.H., or representation from the P.C., or requisition of ten ratepayers, stating that any trade, business, process, or manufacture carried on in any premises and causing effluvia is a nuisance, or injurious or dangerous to the health of any of the inhabitants of the district, may, and, if required by the L.G.B., must, apply to the sheriff by summary petition. The sheriff, being satisfied as to the facts, may fine the author of the nuisance, or in default, the occupier, or failing him, the owner of the premises, unless it is shown that the best practicable means have been used for removing the nuisance or preventing or counteracting the effluvia. (2) The court may give the person charged an opportunity of removing the nuisance or otherwise remedying matters. (3) The L.A. may apply to the Court of Session, instead of the sheriff, in cases brought under their notice by the certificate of the M.O.H. (4) If the nuisance arise outside their district, the L.A. must apply to a sheriff having jurisdiction in the district where it arises.

S. 37.—(1) The removal of house and street refuse by a L.A., when collected and deposited by the L.A. or person authorised by them, is declared to be a business carried on by the L.A. or such person, and as such comes under the provisions of s. 36, which may be applied in any district other than a burgh by the C.C., or in any district by any person authorised by the L.G.B. (2) Any premises used by a L.A., or other person with their authority, for the treatment or disposal of any street or house refuse (as distinct from the removal thereof), which are a nuisance, or injurious or dangerous to health, may be dealt with summarily under this Act as a nuisance, the C.C. or person authorised by the L.G.B. being the executive authorities.

B.P.(S.)A., 1892.

Empowers the Burgh Commissioners to make by-laws for—(*a*) inspecting all places where horses are killed and carrion is kept or sold, and keeping such places in a cleanly or proper state, and removing the filth therefrom, and requiring that all such places shall be provided by the occupiers with proper paving, drainage, and a sufficient supply of water; (*b*) regulating the time and mode of the removal of any offensive matter or thing; (*c*) reducing or removing the noxious or injurious effects attending the business of a blood-boiler, bone-boiler, tanner, slaughterer of horses or animals of any description, soap-boiler, tallow-melter, tripe-boiler, or other noxious or offensive business, trade, or manufacture.

The Act provides for the establishment or licensing of slaughter-houses by the Commissioners, and also for the licensing of persons using such slaughter-houses, and for the licensing of the erection of new slaughter-houses (private). The M.O.H. must report at least twice a year on the sanitary condition of all slaughter-houses. The Commissioners must make by-laws for the inspection, regulation, cleansing, removal of filth, construction, and water supply of slaughter-houses, and for the prevention of cruelty in slaughter-houses. If the Commissioners provide slaughter-houses, no other place within the burgh may be used for the purpose.

Scavenging and Cleansing.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892; L.G.(S.)A., 1894.
In addition, Model By-laws (p. 494).

P.H.(S.)A., 1897.

Provisions.—This Act in this connection applies to landward areas in contradistinction to burghs which come under the B.P.(S.)A., 1892. Under the L.G.(S.)A., 1894, the D.C., or in counties not divided into districts, the C.C., may form special districts for scavenging and certain other purposes, if requested so to do by the P.C. or any ten electors.

S. 38 provides an appeal to the sheriff against the resolution of the D.C. or C.C. forming a special scavenging district.

S. 39.—In special scavenging districts, the D.C. or C.C. may either cleanse or scavenge the highways or footpaths themselves, or may pay a part of the cost. In special scavenging districts, the D.C. or C.C. may cause the owners of premises fronting, adjoining, or abutting any private street or footway to repair and make good such street or footway within a specified time. In default, the authority may do the work and charge the owners; but the owners may appeal to the sheriff against the order of the authority.

S. 40.—The L.A. may compel the owner or occupier to purify any house or article, when it appears to the L.A. that—(1) any house or part thereof, or any article of bedding or clothing therein, is in such a filthy or unwholesome condition that the health of any person is affected or endangered thereby; or (2) that the whitewashing, cleansing, or purifying of any house or part thereof, or any article of bedding or clothing therein, would tend to prevent or check infectious disease. Failure to comply entails a penalty, and the L.A. may do the work themselves, and recover the costs.

S. 41 provides for L.As. obtaining an order from a sheriff for cleansing offensive boundary ditches.

S. 42.—In special scavenging districts, any L.A. may give notice requiring the periodical removal of manure or other refuse matter from mews, stables, or other premises, except cattle courts; and where it appears to the S.I. that any accumulation of manure, dung, soil, or filth, or other offensive or noxious matter, ought to be removed, the S.I. must give notice to the owner of such accumulation, or to the occupier of the premises, to remove the same within forty-eight hours, and if this notice be not complied with, the L.A. may sell the accumulation with the usual proviso.

B.P.(S.)A., 1892.

The Burgh Commissioners must cause all streets and footpaths to be properly swept and cleansed, must collect street dust and rubbish, manure, privy contents, etc., and remove them at convenient times. The owner must, for this purpose, provide sufficient access to any dungstead, ashpit, or privy. The Commissioners may provide lands, etc., for the deposit of soil and materials, and send round covered carts for the removal of refuse generally. They may erect and maintain public conveniences, and water the streets.

The occupiers residing on any common stair shall keep such stair, and any passages and any conveniences used in common, clean to the satisfaction of the

S.I. Common stairs and dwelling-houses let for short periods shall be cleansed and whitewashed by the owners once every year. The M.O.H., surveyor, or S.I., may enter and cleanse dwelling-houses at the expense of the owners. All dwelling-houses, yards, areas, stables, and byres must be kept clean by the occupier, under penalty. Horse or cow dung must be kept off the streets.

There is a penalty for conveying offensive matter at improper times through the burgh, for using for the purpose a cart without a proper covering, for wilfully or negligently spilling offensive matter, and for failing to carefully sweep and cleanse every place in which such offensive matter has been placed or spilled. If the M.O.H. certifies any deposit of manure in gardens, nurseries, etc., to be offensive or prejudicial to health, the magistrate may order its removal.

The Commissioners may make by-laws for the regulation of cleansing.

Unsound Food.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892.

P.H.(S.)A., 1897.

Provisions.—S. 43.—(1) Any M.O.H., or S.I., or veterinary surgeon authorised by the L.A., may at all reasonable times enter any premises within the district of the L.A., or search any cart or vehicle, or any barrow, basket, sack, bag, or parcel, in order to inspect or examine, and may inspect and examine—(*a*) Any animal, alive or dead, intended for the food of man which is exposed for sale or deposited in any place, or is in course of transmission for the purpose of sale or of preparation for sale; and (*b*) any article, whether solid or liquid, intended for the food of man and sold or exposed for sale, or deposited in any place, or in course of transmission for the purpose of sale or of preparation for sale. If any such animal or article appear to be diseased, or unsound, or unfit for the food of man, the M.O.H., S.I., or veterinary surgeon may seize and carry away the same himself, or by an assistant, in order to have the same dealt with summarily by a sheriff, magistrate, or justice. The M.O.H., or S.I., unless himself a qualified veterinary surgeon, must be accompanied by a veterinary surgeon in the case of any proceeding with regard to a living animal. The onus of proof that the unsound food was not exposed or deposited, or in course of transmission for any such purpose, or was not intended for the food of man, rests with the person charged. The police force is empowered to search carts, etc., and to assist generally in executing this section. (2) If the sheriff, magistrate, or justice is satisfied that the food is unsound, he must condemn it, and order it to be destroyed or so disposed of as to prevent it from being exposed for sale or used for the food of man. He may impose a penalty, unless the accused proves that he did not know, and could not with reasonable care have known, that it was in such a condition. The sheriff may impose the penalty of imprisonment, for not more than three months with or without hard labour, if the offence has been committed knowingly and wilfully. If the accused proves that the animal, or part thereof, condemned was before slaughter examined, passed, and certified by a veterinary surgeon approved by the L.A., he is exempt from penalty or imprisonment. (3) The L.A., or combined L.As., may appoint places and fix times at which an authorised veterinary surgeon shall attend to examine any animal, alive or dead, to pass or condemn the same, and to grant certificate of passing. If he condemn it, the L.A. must retain and forthwith destroy the condemned part, or so dispose of it as to prevent it from being exposed for sale or used for the food of man. A carcase must be submitted for examination as a whole carcase, including thoracic and abdominal viscera. (4) Proceedings may be taken against the original vendors of an unsound animal or article of food. (5) The veterinary surgeon must send to the chief constable a copy of any certificate granted by him, and the person selling the animal or carcase must after the sale, and within seven days from the date of the certificate, send the certificate itself to the chief constable. (6) If a person knowingly and wilfully commit and be convicted of such an offence twice within a year, the court may order a notice of the facts to be affixed to the premises occupied by that person, and such notice must not be defaced, removed, or concealed. (7) The occupier of a licensed slaughter-house convicted under this section may have his licence cancelled. (8) Obstruction of the M.O.H., S.I., or veterinary surgeon in the execution of this section entails a fine, or if it be a second offence within a year, or be done with intent to prevent the discovery of an offence, the sheriff may imprison the offender for not more than one month.

B.P.(S.)A., 1892.

Any inspector, collector, or constable may seize any cattle infected with, or suspected of, any disease within the meaning of the D.(A.)A., 1894, which are exposed or offered for sale, or which are being brought through any street or into any market, and may cause the same to be inspected by a veterinary surgeon. A magistrate may order destruction of such cattle or any article infected by them. There is a penalty if the offence of bringing cattle, etc., be committed knowingly. The burgh authorities have the same power of proceeding against the original vendor of unsound food as is granted by the P.H.(S.)A., 1897.

Part III.—GENERAL PREVENTION AND MITIGATION OF DISEASE.

Infectious Disease.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892; I.D.N.A., 1889 (p. 522); C.D.(A.)A., 1878, 1886 (p. 526); D.(A.)A., 1894 (p. 576); F.&W.A., 1901 (p. 574, *c*). In addition, D.C.M.O. (p. 546); Regulations of the L.G.B. (p. 537).

P.H.(S.)A., 1897.

Provisions.—S. 44.—*Notification.*—This section applies the I.D.N.A., 1889, to every district in Scotland, whether it has or has not been previously adopted. For its provisions, see p. 522.

Prevention.—S. 45.—The M.O.H. may, at reasonable times in the daytime, enter and inspect any house or premises in the district, in which he has reason to believe that any infectious disease exists, or has previously existed, and the M.O.H. may examine any person found on such premises. If admission, inspection, or examination is refused, a sheriff, magistrate, or justice may grant a warrant, and there is a penalty provided for non-compliance with the terms of the warrant. The term "infectious disease" is not here limited to those specified in the I.D.N.A., but includes all infectious diseases.

S. 46.—(1) Every L.A. may, and if required by the L.G.B., must, provide, either within or without their district, proper premises with all necessary apparatus and attendance for the destruction and for the disinfection of, and carriages and vessels for the removal of, articles (whether bedding, clothing, or other) which have become infected by any infectious disease. The L.A. must undertake the destruction or disinfection of such articles and their return. They may remove, destroy, or disinfect and return such articles free of charge. (2) L.As. may combine for this purpose, or a L.A. may contract for the use of the necessary premises and appliances.

S. 47.—(1) Where it appears to the L.A., upon the certificate of the M.O.H., or any other registered medical practitioner, that the cleansing or disinfecting of any house or part thereof, and of any articles therein likely to retain infection, or the destruction of such articles, would tend to prevent or check any infectious disease, the L.A. may serve notice on the occupier, or if the house be unoccupied, on the owner, that the house and any such articles therein will be cleansed and disinfected, or (as regards the articles) destroyed by the L.A., unless the person so notified undertakes, within a specified time, to do the work to the satisfaction of the M.O.H. or medical practitioner. (2) The L.A. must carry out the disinfection, etc., if the promise is not given within a specified time, or if it is not fulfilled within a specified time, or if the occupier or owner, without such notice, gives his consent. (3) Confers powers of entry by day on the L.A. for the purpose of carrying into effect this section. (4) The L.A. may provide temporary shelter or house accommodation, and if necessary, maintenance, with any necessary attendance, free of charge, for any residents who, not being themselves sick, are removed from any house or tenement on account of the existence or recent existence therein of infectious disease, or for the purpose of disinfecting such house or tenement. If the consent of any such resident or his parent or guardian is obtained, no warrant is necessary for the removal, otherwise the L.A. must apply to the sheriff, magistrate, or justice for a warrant. (5) The L.A. must pay compensation for any unnecessary damage caused during disinfection, and for the destruction of any article in such house. For the purpose of sec. 47 the word *house* includes any tent or van, or any ship lying in any sea, river, harbour, or other water, or ex adverso of any place within the limits of the L.A.

S. 48.—(1) The L.A. may require the delivery (for removal for the purpose of destruction or disinfection) of any bedding, clothing, or other articles which have been exposed to the infection of any infectious disease. (2) The paying of compensation applies also to any articles removed for disinfection and destruction.

S. 49.—If the M.O.H. certify that such a course is desirable, with a view to prevent the spread of infectious disease, the L.A. may require any person or company earning a livelihood or deriving gain by the washing or mangling of clothes, to furnish to them a full and complete list of the names and addresses of the owners of clothes for whom such person or company has washed or mangled during the past six weeks. The L.A. must pay sixpence for every list, and at the rate of sixpence for every twenty-five names contained therein, but the payment shall not exceed three shillings for any one list.

S. 50.—(1) No person may knowingly cast, or cause or permit to be cast, into any ashpit, nor may otherwise expose, any matter or article infected by infectious disease. (2) The L.A. must cause their officers to serve notice of the provisions of this section on the occupier of any house, or part of a house, in which they are aware that there is a person suffering from an infectious disease.

S. 51.—(1) Any person who knowingly lets for hire any house, or part of a house, in which any person has been suffering from any infectious disease, without having such house, or part of a house, and all articles therein liable to retain infection, disinfected to the satisfaction of the M.O.H., as testified by a certificate signed by him, or (as regards the articles) destroyed, is liable to a penalty. (2) This section applies to the keeper of an inn or hotel, who is deemed to let for hire part of a house to any person admitted as a guest into such inn or hotel.

S. 52.—Any person letting for hire, or showing for the purpose of letting for hire, any house or part thereof, who, on being questioned by any person negotiating for the hire as to the fact of there being, or within six weeks previously having been, therein any person suffering from any infectious disease, knowingly makes a false answer to such question, is liable to a fine, or, if the proceedings are before a sheriff, to imprisonment with or without hard labour for a period not exceeding one month.

S. 53.—(1) Where a person ceases to occupy any house, or part of a house, in which any person has within six weeks previously been suffering from any infectious disease, and either—(*a*) fails to disinfect the house and its contents to the satisfaction of the M.O.H., or to destroy infected articles; or (*b*) fails to give notice of the previous existence of such disease to the owner or occupier; or (*c*) knowingly makes a false answer when questioned by the owner, occupier, or any person negotiating for hire of such house, as to the fact of there having, within six weeks previously, been therein any person suffering from infectious disease, is liable to a penalty. (2) The L.A. must serve a notice of the provisions of this section on the occupier of any house in which they are aware that there is a person suffering from an infectious disease.

S. 54.—(1) A person suffering from any infectious disease who is without proper lodging or accommodation, or is so lodged that proper precautions cannot be taken to prevent the spread of the disease, or is lodged in a tent or van, or in a room occupied by others besides those necessarily in attendance on such person, or is on board a ship, may, on a certificate signed by the M.O.H., or a medical practitioner, and with the consent of the superintending body of the hospital to which he is to be removed, be removed by order of a sheriff, magistrate, or justice, on the application and at the cost of the L.A., to any hospital in or near their district.

Such a person may be detained in hospital as long as he continues in an infected condition, and no order is necessary for his removal to hospital if the patient or his parent or guardian give consent.

Alternatively, the L.A. may obtain an order for the removal of all persons from the house, etc., except the infected person and those in attendance on him, and may provide suitable accommodation for them. (2) The removal may be carried out by the police or the officers of the L.A., and any obstruction or wilful disobedience renders liable to a penalty.

S. 55.—(1) An infected person in a hospital, who, on leaving hospital, would be unprovided with proper lodging in which proper precautions could be taken to prevent the spread of disease, may be detained in the hospital by order of the sheriff, magistrate, or justice, on the application of, and at the cost of the L.A. The length of detention is specified in the order, and may be increased if necessary; and (2) the order may be executed by the police, the officers of the L.A., or the officers of the hospital.

S. 56.—(1) (*a*) No person suffering from any infectious disease may wilfully expose himself, without proper precautions against spreading the disease, in any street, public place, shop, inn, hotel, church, or any place used in common by persons other than members of the family or household to which such infected person belongs. (*b*) No person in charge of any such sufferer may wilfully expose him. (*c*) No person may knowingly give, lend, sell, pawn, transmit, remove, expose, or permit to be washed or exposed in any wash-house or washing-green (used in common by persons other than those belonging to the infected family), any infected bedding, clothing, or other infected article, without previous disinfection to the satisfaction of the M.O.H., or medical practitioner, as certified by him in writing. (*d*) No person may wake or permit to be waked any infectious corpse in any house, room, or place over which he has control. A penalty is provided for contravention of each of these subsections. (2) Bedding, clothing, or other articles being transmitted for purposes of disinfection are not included under (1) (*c*).

S. 57.—No parent or person having charge of a child who is or has been suffering from infectious disease, or resides in a house where such disease exists or has existed within three months, may knowingly or negligently permit such child to attend school without a certificate of freedom from infection. Such a certificate must be delivered to the teacher, and may be granted by the M.O.H. free of charge, or by a medical practitioner, and it must also state that the house and contents have been disinfected to his satisfaction. A person liable only in default of another person to obtain and send such a certificate may successfully plead that he had reasonable cause to suppose that the notice had been duly sent.

A teacher or person in charge of any school knowingly permitting any such child to attend school is also liable to a fine.

S. 58.—No person infected or living in an infected house may milk any animal, pick fruit, or engage in any occupation connected with food, or in any trade or business in such a manner as to be likely to spread such disease.

S. 59.—It is not lawful for any owner or person in charge of a public conveyance or ship knowingly to convey therein, or for any other person knowingly to place therein, a person suffering from any infectious disease. Further, no person so suffering may enter any public conveyance or ship; and if he is conveyed therein, the owner or person in charge must give notice to the L.A., and must disinfect such conveyance or ship. The expense of disinfection may be recovered from the person at fault. It is the duty of the L.A., when requested by the owner, to disinfect such conveyance or ship, and they may do so free of charge. Nothing in this section prevents the removal by train or ship of infected persons if they are in an ambulance waggon or other proper vehicle provided by the L.A.

S. 60.—(1) If the M.O.H. of any district has evidence that any person in the district is suffering from any infectious disease due to milk supplied from any dairy in the district, or that the milk from any such dairy is likely to cause any such disease, the M.O.H. must visit the dairy (no warrant being necessary) and examine the dairy and every person engaged in the service thereof, or resident upon the premises, or residing with the employees. If accompanied by a veterinary surgeon, the M.O.H. may examine the animals in the dairy, and both must report to the L.A. (2) A dairy outside the district of the L.A., under the same conditions as in the previous subsection, may be similarly inspected and reported upon at the instance of their M.O.H. Thereupon the L.A. of the district in which the dairy is situate must forthwith, by their own M.O.H. and veterinary surgeon, examine the dairy, persons, and animals, receive a report from these officers, and give an opportunity to the complainant L.A. to be represented at the examination by their M.O.H. and veterinary surgeon. (3) The L.A. of the district in which the dairy is situated, or any committee appointed for the purpose, must meet forthwith, consider the reports and any evidence submitted by parties concerned, and must either make an order requiring the dairyman not to supply any milk from the dairy until withdrawal of the order by the L.A., or resolve that no such order is necessary. (4) There is no appeal to the C.C. against any order or proceedings under this section. (5) The L.A. may, if the dairy is within the district, require the dairyman not to supply milk either within or without the district, and must notify the fact to the L.A. of any district within which milk may be supplied from such dairy. (6) Any such order must be forthwith withdrawn on the L.A. or the M.O.H. being satisfied that the milk from the dairy is no longer likely to cause infectious disease. (7) Any L.A. or dairyman aggrieved by any resolution, order, or withdrawal of order, may appeal to the sheriff of the district in which the dairy is situated. Pending the disposal of any such appeal, the order remains in force. The sheriff may order the dairyman to cease from supplying milk, or may vary or rescind any order of the L.A., or withdraw any order made under this section. (8) Any obstruction to the examination or contravention of the order renders liable to a penalty, and a daily continuing penalty. (9) It is provided that proceedings in respect of offences against this section must be taken before a sheriff having jurisdiction in the place where the dairy is situate, and that a dairyman shall not be liable to an action for breach of contract if the breach be due to his compliance with an order. (10) Nothing in or done under this section shall interfere with other Acts on this and allied subjects, namely, the C.D.(A.)A., 1878 and 1886; D.C.M.O., 1885, or other general Act.

S. 61.—When the M.O.H., or a medical practitioner, certifies to the L.A. that in his opinion the outbreak or spread of infectious disease within the district is attributable to milk supplied by any dairyman, wholesale or retail—(1) The L.A. may require such dairyman, whether within or without their district, to furnish them, within a specified time, not less than twenty-four hours, with a complete list of the names and addresses of all his customers, and shall pay him for every such list at the rate of sixpence for every twenty-five names. (2) The L.A. may require such dairyman to furnish, within a specified time, a full and complete list of the names and addresses of the farmers, dairymen, or other parties from whom, within a period to be specified, the milk or any part of the milk sold or distributed by him was obtained. The dairyman may be required to submit his books to the M.O.H. or any person deputed by him. Offences against these subsections are punished by penalty and a continuing daily penalty.

S. 62.—It is unlawful without the written sanction of the M.O.H., or a medical practitioner, to retain unburied for more than forty-eight hours, elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or workroom, the body of any person who has died of any infectious disease. (Penalty not exceeding £5.)

S. 63.—The body of a person who has died of any infectious disease in a hospital, whether permanent or temporary, must only be removed for burial and be forthwith buried, if the M.O.H., or a medical practitioner certifies that such body may spread infection. For the purposes of this section a mortuary is regarded as a part of the hospital. (Penalty not exceeding £10.)

S. 64 provides for the disinfection of public conveyances, other than hearses, if used for carrying the bodies of persons who have died of infectious disease. Any person who hires or uses such public conveyance, and does not previously notify the owner or driver, and any owner or driver who does not at once inform the L.A. of such use, and provide for the disinfection of such conveyance to the satisfaction of the L.A., and who does not take all reasonable precautions to prevent the spread of infection immediately on its coming to his knowledge that such conveyance is being or has been used for conveying such body, is liable to a penalty of £5, and to a daily continuing penalty of 40s.

S. 65.—The L.A. may make by-laws for securing the cleanliness and sanitary condition of public conveyances plying within their district, and for preventing overcrowding in such conveyances.

B.P.(S.)A., 1892.

It is the duty of the M.O.H. of a burgh to ascertain the existence of disease within its limits, especially of all infectious diseases, and to point out any local causes likely to occasion or continue such diseases, or otherwise injure the health of the inhabitants, and to point out the best means of checking or preventing the spread of such diseases. This is in addition to the duties assigned to the M.O.H. under the P.H.(S.)A.

Hospitals and Ambulances.

Act Concerned.

P.H.(S.)A., 1897.

Provisions.—S. 66.—(1) Any L.A. may, and if required by the L.G.B., must, provide, furnish, and maintain hospitals, temporary or permanent, for infectious diseases, and houses of reception for convalescents from infectious diseases, or for persons who have been exposed to infection. The L.A. may themselves build, or contract for the use of, any such hospital or house, or may enter into any monetary agreement with the managers of such a hospital or house for the reception of patients therein. A L.A. with consent of the L.G.B. may, in addition to or in place of providing such hospitals or houses, employ nurses to attend the patients suffering from infectious disease in their own houses, and may supply medicines and medical attendants for such sick.

The L.A. possess no power to recover the cost of maintenance and treatment of any patient in the hospital; but, on the other hand, they are under no obligation to admit better class patients, and may make payment a condition of such admission.

(2) Two or more L.As. may, and if required by the L.G.B., must, combine for the purposes detailed above, and the L.G.B. is the arbiter in the agreement between them.

(3) The site and plans of, and contracts for, such hospital must be approved by the L.G.B. The site must be in or near the district of the L.A. or L.As. to be served by it.

(4) Portable hospitals may be provided by a L.A., with the consent of the L.G.B.

S. 67.—Carriages suitable for the conveyance of persons suffering from any infectious disease may be provided and maintained by the L.A., and the expense of conveying therein any person so suffering to a hospital or other place of destination may be paid by the L.A.

Mortuaries.

Acts Concerned.

P.H.(S.)A., 1897; Burial Grounds (Scotland) Act, 1855. In addition, Model By-laws and Suggestions of the L.G.B. (p. 527).

P.H.(S.)A., 1897.

Provisions.—S. 68.—Every L.A. may provide and fit up one or more mortuaries, and may by by-law regulate the management and charges for the use of such.

S. 69.—(1) Where either—(*a*) the body of a person who has died of any infectious disease is retained in a room in which persons live or sleep; or (*b*) the body of a person who has died of any infectious disease is retained without the sanction in writing of the M.O.H., or any legally qualified medical practitioner, for more than forty-eight hours, elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or workroom; or (*c*) any dead body is retained in any house, or room, or ship under circumstances which, if continued, may endanger the health of the inmates thereof, or of any adjoining or neighbouring house or building; or (*d*) any dead body found within the district is unclaimed, or no sufficient person undertakes to bury it, a sheriff, magistrate, or justice may, on a medical certificate, direct that the body be removed, at the cost of the L.A., to any available mortuary, and be buried within a specified time; and may, if it is the body of a person who has died of any infectious disease, or if he considers immediate burial necessary, direct that the body be buried immediately, without removal to the mortuary. (2) If the friends or relations fail to so bury such body within the specified time, the L.A. must do so, and may recover the cost. (3) It is unlawful to transport the body of any person who has died of any infectious disease, by railway or other public conveyance, without a medical certificate that every precaution necessary for the public safety has been adopted. An undertaker knowingly removing such a body without such certificate, and any person who procures or endeavours to procure the removal of such dead body without having obtained such certificate, is liable to a penalty of £5. (4) The same penalty attaches to obstruction to the execution of any direction of a sheriff, magistrate, or justice.

S. 70.—(1) A L.A. may provide and maintain a proper building (otherwise than at a poorhouse) for the reception and official post-mortem examination of dead bodies. The L.A. may make regulations respecting the management of such building. (2) The post-mortem room may be connected with a mortuary, but this does not authorise the conducting of any post-mortem examination in the mortuary.

S. 71.—L.As. may combine or arrange for the establishment or use of mortuaries and post-mortem rooms.

B.G.(S.)A., 1855.

Parish or Town Councils are empowered by this Act to provide places for the reception of the dead previous to interment, and the Secretary for Scotland may issue regulations for these places for the protection of the public health and the maintenance of public decency.

Houses Let in Lodgings.

ACTS CONCERNED.

P.H.(S.)A., 1897; Merchant Shipping Act, 1894 (p. 509).
In addition, Model By-laws (p. 509).

P.H.(S.)A., 1897.

Provisions.—S. 72.—(1) Every L.A. may, and if required by the L.G.B., must, make and enforce, for the whole or any part of their district, by-laws —(*a*) for fixing the number of persons who may occupy a house, or part of a house, which is let in lodgings or occupied by members of more than one family; (*b*) for the registration of houses so let or occupied; (*c*) for the inspection of such houses; (*d*) for enforcing sufficient privy or water-closet accommodation, and other appliances and means of cleanliness in proportion to the number of lodgers or occupiers, for drainage for such houses, and for promoting cleanliness and ventilation, and for the cleansing and ventilation of the common passages and staircases; (*e*) for the cleansing and limewashing of the premises at stated times; (*f*) for the giving of notices and the taking of precautions in the case of any infectious disease. (2) This section does not apply to common lodging-houses, which are governed by other provisions of this Act, but it applies to farmed-out houses, *i.e.* houses of one or two apartments taken on lease by any person, and let or rented to several occupiers for limited periods as furnished apartments. It also applies to all boarding-houses for seamen and emigrants irrespective of the charge made for board and lodging therein.

Tents and Vans (Moveable Dwellings).

ACTS CONCERNED.

P.H.(S.)A., 1897; H.W.C.A., 1885, s. 9 (p. 558). In addition,
Model By-laws (pp. 557, 558).

Provisions.—S. 73.—(1) A tent, van, shed, or similar structure used for human habitation which is in such a state as to be a nuisance, or injurious or dangerous to health, or is so overcrowded as to be injurious or dangerous to the health of the inmates, is a nuisance liable to be dealt with summarily. (2) The L.A. may make by-laws for promoting cleanliness in, and the habitable condition of, tents, vans, sheds, and similar structures used for human habitation, and for preventing the spread of infectious disease by persons inhabiting the same, and generally for the prevention of nuisances. (3) The M.O.H., or S.I., having reasonable cause to believe either (*a*) that any tent, van, etc., used for human habitation is in the condition above mentioned, or that there is any contravention of any by-law made under this section; or (*b*) that there is in any tent, van, etc., any person suffering from an infectious disease, or that any infectious disease has recently existed therein, may enter at reasonable times in the daytime and examine the structure, and the M.O.H. may examine any person found therein. (4) The section does not apply to any tent, van, etc., erected or used by any portion of His Majesty's naval or military forces.

Underground Dwellings.

Act Concerned.

P.H.(S.)A., 1897.

Provisions.—S. 74.—It is unlawful to let separately, except as a warehouse or storehouse, or to suffer to be occupied as a dwelling-place, any cellar or any vault, or underground room, which does not comply with the following conditions:—(1) Its height in every part from floor to ceiling must, if built before January 1, 1898, be 8 ft., if built thereafter, 9 ft. (2) Not less than one-third of its height, or alternatively 3 ft. of its height, must be above the level of the adjoining street or ground. (3) It must have an open area $2\frac{1}{2}$ ft. wide from the level of the floor up to the street or ground-level. (4) It must have the use of a water-closet, earth-closet, or privy, and of an ashpit. (5) It must have a glazed window at least 9 square ft. in area clear of the frame, and this window must be made to open to half its extent. (6) It must have a fireplace with a chimney or flue. (7) If it is an inner or back vault or cellar let or occupied along with a front vault or room, it must have a ventilating flue, unless the house was built before January 1, 1898. (8) It must be well and effectually drained by means of a drain constructed of a gas-tight pipe, or otherwise effectually sealed. The upper circumference of the drain must be at least 1 ft. below the level of the floor. These requirements are essential whether the cellar, vault, etc., be conjoined or not with another apartment, unless the latter have one of its external sides entirely above the level of the street or ground adjoining the same, and have a window or other opening in that side. It is the duty of the L.A. to issue notices to the owners prohibiting the letting or occupation of cellars, vaults, etc., as dwelling-places if they do not comply with the above requirements, and after receipt of such notice, the owner is liable to a penalty if he let, continue to let, occupy, or suffer to be occupied, such cellar, vault, or underground room. The L.A. must continue to issue such notices until a notice has been given with regard to every cellar, vault, or underground room occupied as a dwelling-house within the district.

S. 75 provides a penalty of 20s. per day after conviction for the first offence.

S. 76.—If two convictions occur within three months, relating to the occupation of any cellar, vault, or underground room, the sheriff may direct the closing of such premises for such time as he may deem necessary, and may empower the L.A. to permanently close the same in such manner as they may deem fit.

Vaccination.

ACTS CONCERNED.

P.H.(S.)A., 1897; General Vaccination Acts (p. 577).

P.H.(S)A., 1897.

Provisions.—S. 77.—The L.A. may defray the cost of vaccinating or re-vaccinating such persons as to them may seem expedient.

PART IV.—PREVENTION OF EPIDEMIC DISEASES.

ACTS CONCERNED.

P.H.(S.)A., 1897; Merchant Shipping Act, 1894 (p. 537); Orders and Regulations of the L.G.B. (p. 537).

P.H.(S.)A., 1897.

Provisions.—The L.G.B. may from time to time make, alter, and revoke regulations with a view to the treatment of persons affected with any epidemic, endemic, or infectious disease, and preventing the spread of such diseases as well on the seas, rivers, and waters of Scotland, and on the high seas within 3 miles of the coast thereof, as on land. The L.G.B. may further declare by what authority or authorities such regulations may be enforced and executed.

S. 79.—In the event of any formidable epidemic, endemic, or infectious disease threatening or infecting the country, the L.G.B. may make, and from time to time alter and revoke, regulations—

1. For the speedy interment of the dead.
2. For house-to-house visitation.
3. For the provision of medical aid, dispensing of medicine, and accommodation, for the promotion of cleansing, ventilation, and disinfection, and for guarding against the spread of disease.
4. For any such matters or things as may to them appear advisable for preventing or mitigating such disease.

The L.G.B. may, by order, apply such regulations to the district of any L.A., and to any ships, whether in ports or adjacent waters.

S. 80.—Such regulations and orders must be published in the *Edinburgh Gazette.*

S. 81.—The L.A. are responsible for the execution of such regulations, and must aid their enforcement in every possible way.

S. 82.—The L.A. and their officers are given powers of entry to assist the enforcement of these regulations.

S. 83.—The L.G.B. may combine two or more L.As. for this part of the Act, and may prescribe their mode of action.

S. 84.—In any place where such regulation of the L.G.B. is in force, and where, on the certificate of a M.O.H., or of two medical practitioners, or on the report of a S.I., or other sufficient evidence, it is apparent to the L.A. that any house, or part of a house, is so overcrowded as to be dangerous to health, the L.A. may regulate the same by applying the provisions of this Act relating to C.L.H.

S. 85.—Regulations of the L.G.B. may be enforced and executed by officers of Customs, officers and men of the coastguard, as well as by other authorities and officers, as regards—(*a*) the signals to be hoisted by vessels having any epidemic, endemic, or infectious disease on board; (*b*) questions to be answered by masters, pilots, and other persons on board any vessel as to cases of such disease on board during the voyage or on arrival of the vessel; (*c*) the detention of vessels and of persons on board vessels; (*d*) the duties to be performed in cases of such disease by masters, pilots, and other persons on board vessels.

S. 86.—It is expedient that such regulations should be uniform throughout the whole of the United Kingdom.

S. 87.—Wilful neglect of, refusal to obey or carry out, and obstruction of the execution of, any such regulations is punished by a penalty not exceeding £100, and a further daily continuing penalty not exceeding £50.

S. 88.—Powers formerly belonging to the Privy Council are now exercised by the L.G.B.

Part V.—COMMON LODGING-HOUSES.

Acts Concerned.

P.H.(S.)A., 1897. In addition, Model By-laws (p. 507), and Recommendations of the L.G.B.

P.H.(S.)A., 1897.

Definition.—C.L.H. (p. 579).

Provisions.—S. 89.—The L.A. must cause a register to be kept, in which shall be entered the names and residences of the keepers of all C.L.H. within their district, the situation of every such house, and the number of lodgers authorised by the L.A. to be kept therein, and in each apartment thereof. Registration must be renewed annually, and the L.A. may refuse registration if they consider the house unsuitable or its keeper unqualified, even if he produce the requisite certificate of character. The L.A. may, with the approval of the L.G.B., raise or lower the sum payable per night, but such sum shall not exceed sixpence per night.

S. 90.—No house must be used as a C.L.H., and no lodger received therein, until the house has been inspected by the I.C.L.H., approved by the L.A., and entered in the register. The permanent or temporary removal of a C.L.H. from the register, if the L.A. consider that the C.L.H. or the keeper has ceased to be suitable for the purpose, is permitted if the L.A. present a petition to the sheriff and obtain his authority by warrant.

S. 91.—A copy of an entry in the register, certified by the person in charge of the register, is received as evidence, and a certified copy may be obtained for twopence from the person in charge.

S. 92.—The L.A. may make by-laws for C.L.H. in respect of the following matters:—(*a*) For the keeping and well-ordering of such houses; (*b*) for the separation of the sexes therein; (*c*) for fixing the number of lodgers which may be received in each such house and in each room therein; (*d*) for enforcing sufficient privy or water-closet accommodation and other appliances and means of cleanliness in proportion to the number of lodgers and occupiers, as also proper drainage and ashpits for such houses; (*e*) for promoting the cleanliness and ventilation of such houses; (*f*) for the inspection thereof, and the conditions and restrictions under which such inspection may be made.

S. 93.—The L.A. must supply gratis to every keeper of a C.L.H. a copy of the by-laws made by them and confirmed by the L.G.B. The keeper of a C.L.H. must hang up a copy of the by-laws in some conspicuous place in each room in which lodgers are received.

S. 94.—If a C.L.H. is without a proper supply of water, or without sufficient privy or water-closet accommodation, and if a supply of water can be furnished thereto at a reasonable rate, the L.A. may, by written notice, require the owner or keeper to obtain such a supply, and to execute all necessary works within a specified time. The L.A. may remove the C.L.H. from the register until such notice is complied with, but the owner or keeper or any person interested may appeal against the removal. The appeal is to the sheriff in the case of burghs, and to the C.C. in the first instance, and afterwards to the sheriff, in the case of landward areas.

S. 95.—The L.A. may, by order, require the keeper of a C.L.H. to report, on schedules provided by the L.A., every person who resorted to such C.L.H. during the preceding day or night.

S. 96.—The L.A. may remove to hospital any person ill of infectious disease in a C.L.H. No warrant is required, but the consent of the hospital authorities must be obtained, and also a certificate from the M.O.H., or a medical practitioner, that the disease is infectious, and that the patient may be safely removed. If it be similarly certified that removal of the patient would be dangerous to life, no lodger may be admitted to the C.L.H. until it is certified free of infection. The L.A. may, in order to prevent the spread of disease, disinfect or destroy any clothes or bedding used by such person, and may pay to the owners reasonable compensation for injury or destruction of such articles.

S. 97.—The keeper of a C.L.H. must give immediate notice to the M.O.H., or the I.C.L.H., when a person in such house is ill of any infectious disease. The I.C.L.H. must forthwith inform the M.O.H., and if the M.O.H. is satisfied that the person is suffering from an infectious disease, he must cause the patient to be removed without delay, and the premises to be disinfected. If the M.O.H. consider that the patient cannot be removed with safety, neither the house nor any part thereof must be used as a C.L.H. until the M.O.H. certify such house, or part thereof, as free from infection. The L.A. may provide for the temporary shelter or house accommodation, and, if necessary, the maintenance, of persons prevented from returning to such C.L.H., but the L.A. must not charge for this a larger sum than that usually paid by such persons frequenting the C.L.H.

S. 98.—The keeper of a C.L.H. is bound to give free access to the C.L.H. and to every part thereof at all times when required by any officer of the L.A.

S. 99.—The keeper of a C.L.H. must thoroughly, and periodically, as required by by-law of the L.A., cleanse the whole interior of the C.L.H., its accessories, and sanitary conveniences, to the satisfaction of the I.C.L.H. He must also well and sufficiently, to the like satisfaction, limewash the walls and ceilings in the first week of April and of October in each year, and at such other times as the L.A. may appoint or direct by Special Order.

S. 100.—If a keeper of a C.L.H. be convicted of three or more offences under this Act, he may be disqualified for a period not exceeding five years from keeping or managing a C.L.H.

The S.I. is ex officio I.C.L.H.

RECOMMENDATIONS OF THE L.G.B.

The L.G.B. recommend that L.As. before registering a C.L.H. should insist upon its fulfilling the following requirements :—

1. Structure and Drainage.

The premises should be well drained, and the foundations of the buildings thoroughly dry. The structure should be substantial, and the wall, roof, and floors in good repair. Suitable rhones, gutters, and spouts, properly placed and fixed, and discharging into disconnected or ventilating traps, ought also to be in connection with the roof and outside walls. Any area or yard should be well paved, or otherwise have a surface which can be easily swept and cleansed.

2. Internal Arrangements.

The suitability of the internal arrangements must be carefully considered, special attention being paid to the situation, construction, and state of repair of sinks, basins, water-closets, and cisterns. The waste and soil pipes should be efficiently disconnected and ventilated.

3. Water Supply.

The water supply must be of good quality, and in quantity proportionate to the number of lodgers which the house is registered to accommodate. Where the water is stored in cisterns, these should be properly situated, covered, and not exposed to pollution from sewer-gas or otherwise. Cisterns for the domestic supply should be separate from those provided for water-closets. Where the supply is derived from wells, the L.A. should satisfy themselves that it is secure from any danger of contamination.

4. Cubic Space.

The proper amount of cubic space for each lodger will vary according to circumstances. In rooms of good construction and having ample means of ventilation, not less than 300 cubic ft. for each person may be adequate provision ; but in some cases, as, *e.g.*, in a room where there is no fireplace, or in premises situated in a crowded neighbourhood, a larger provision will have to be made.

5. Ventilation.

All rooms, passages, and stairs should possess means of complete ventilation. All windows should be of adequate size and able to be opened to the full extent. No room should be registered which has not a window opening directly to the outer air.

6. Privy Accommodation.

Closet or privy accommodation should be proportionate to the number of lodgers which the house is registered to accommodate, and should be in the proportion of not less than one closet or privy for every twenty lodgers. These conveniences should be in suitable situations, of proper construction, and in good repair.

7. Washing Accommodation.

This should be ample, and provided in a place set apart for the purpose.

8. Kitchen.

No kitchen or apartment used as such should be registered as a sleeping apartment.

Part VI.—SEWERS, DRAINS, AND WATER SUPPLY.

SEWERS AND DRAINS.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892; R.P.P.A., 1876, 1893 (p. 563); L.G.(S.)A., 1889, 1894. In addition, Model By-laws (p. 498).

P.H.(S.)A., 1897.

Provisions.—S. 101.—With certain exceptions, all sewers within a district, together with all man-ways, lamp-holes, ventilating shafts, cesspools, etc., are vested in the L.A.

S. 102 gives the L.A. power to purchase sewers, provided they pay the legal and necessary compensation.

S. 103.—The L.A. may construct within their district, and also when necessary for the purposes of outfall, distribution, disposal, and treatment of sewage, without their district, such sewers as are necessary. They may carry such sewers through, across, or under any road, street, or place, or under any cellar or vault which may be under the foot-pavement or carriage-way of any street or road. If a surveyor report that it is necessary to carry the sewers into, through, or under any lands, the L.A. may proceed to do so, provided they give reasonable written notice to the owner and occupier. The L.A. has power from time to time to enlarge, lessen, alter, arch over, or otherwise improve, close up, or destroy all sewers vested in them, provided that no nuisance is created by such alterations. If any person is thereby deprived of the lawful use of any sewer, the L.A. shall provide another sufficiently effectual for his use. The L.A. must construct, maintain, keep, and clean their sewers so that these are not a nuisance, and the L.A. may provide what is necessary for such purposes. The L.A. must arrange for the outfall of their sewers, and for the distribution, disposal, or treatment of the sewage either within or without their district, but always subject to the provisions of the R.P.P.A., and to the rule that no nuisance may be created. The L.A. may sell any sewage or refuse.

S. 104.—The L.A. must give at least three months' notice before commencing sewage works outside their district.

S. 105.—In case of any objection, work cannot be commenced without the sanction of the L.G.B.

S. 106.—On application of a L.A. desirous of constructing any sewage work, the L.G.B. may appoint an inspector to report to them regarding it.

S. 107 provides for the protection of railways, canals, etc., liable to be affected by sewerage works.

S. 108.—The L.A. may enter into a contract for the purpose of the utilisation of sewage on land, but no contract shall be made for the supply of sewage for a period exceeding five years, unless authorised by the L.G.B., and not for any period exceeding twenty-five years.

S. 109.—The L.A. possess powers of entry on lands and premises for all work connected with sewers and drains, and if refused entry may obtain warrant from the sheriff.

S. 110.—Owners and occupiers of premises within the district of a L.A., and liable to the public health or special sewer assessment, are entitled to drain their premises into the sewers of the L.A. Twenty days' notice must be given to the L.A., and the junction with the sewer must be made in accordance with the regulations of the L.A. and to the satisfaction of their surveyor. The right is limited by the proviso that the sewage must not be of a nature to cause damage to the sewer, or any nuisance when mixed with other sewage therein.

S. 111.—The L.A. may, on terms fixed by mutual agreement, or summarily by the sheriff in case of dispute, allow owners or occupiers of premises outside their district to drain the premises into their sewers. There is the same proviso as in the previous section.

S. 112.—No person may, without the sanction of the L.A., join any drain to the sewers of the L.A.; and if the act be done, the L.A. may close up the communication, and recover the cost. Penalty for contravention, £5.

S. 113.—Before contracting for any sewerage, drainage, or water-supply work, the L.A. must take estimates if the expense exceed £30.

S. 114.—Unless with the consent of the L.A., no building may be erected over any sewer belonging to the L.A., and no structure made, and no pipes laid, which may interfere with such sewer.

S. 115.—All sewers and drains, whether public or private, must be sufficiently trapped and ventilated. The owners are responsible, and the work must be done to the satisfaction of the L.A.

S. 116.—Owners or occupiers of distilleries, manufactories, and other works must—(*a*) construct pools or reservoirs, within or adjacent to the works, for receiving and depositing the refuse of such works, so far as offensive, or injurious, or dangerous to the health of those living in the vicinity; or (*b*) use the best practicable means for rendering the same inoffensive or innocuous before discharging it into any river, stream, ditch, sewer, or other channel.

S. 117.—No matter or substance by which the free flow of the sewage, or of surface or storm water may be interfered with, or by which a sewer or drain belonging to a L.A. may be injured, may be passed into any sewer or any drain connected therewith. The penalty is £10, and there is a daily continuing penalty of 20s.

S. 118.—No person may throw or suffer to be thrown into any running water, spring, well, lake, pool, reservoir, drain, or ditch, the carcase, whole or part, of any animal. Penalty, £10.

S. 119.—A L.A., with the consent of the Board of Trade and of the Commissioners of Woods and Forests, may construct any works requisite for the outfall of a drain below low-water mark if necessary for the public health.

S. 120.—The owner of any house, distillery, manufactory, or other work which is either without a drain, or without an effectual drain, may be required by the L.A. of the district within a reasonable time to make a sufficient drain. If there be a sewer within 100 yds. from the site of the premises, and if the L.A. may use, and the owner may make a communication with, such sewer, then the drain must be made to empty into that sewer. Otherwise, the drain must empty into such covered cesspool or other place, not being under any house, as the L.A. may direct. On non-compliance, the L.A. may do the work, and recover the costs from the owner. If a new sewer would cost less than a communication with an existing sewer, the L.A. may make the new sewer, may require the owners to connect their drains therewith, may apportion the construction expenses between such owners, and recover them in a summary manner. In case of dispute, the sheriff is the arbiter.

S. 121.—L.As. may combine as to sewerage works.

S. 122.—(1), (2), (3) In landward areas special drainage districts may be formed by the L.A. The procedure may be initiated by the L.A. itself, or upon the written requisition either of a P.C., or of not less than ten ratepayers within the district of the L.A. Twenty-one days' notice must be given, thereafter the L.A. meet and consider the propriety of—(*a*) forming part of their district into a special drainage district; (*b*) enlarging or limiting the boundaries of a special drainage district; (*c*) combining a special drainage district with another special drainage district; (*d*) altering or combining both or either such special drainage districts or parts thereof; (*e*) determining that any special drainage district shall cease to exist as a special drainage district, or that any such combination shall cease. Due publicity must be given to any resolution of the L.A., and a copy sent to the L.G.B., and to the C.C. if the L.A. be a D.C. Any person interested may appeal to the sheriff within twenty-one days, and the sheriff may make such order as he sees fit. (4) The D.C. may provide for the drainage of highways and footpaths. (5) Provides that the provisions of the L.G. Acts remain in force (p. 605).

S. 123.—The making of works of distribution and service for the supply of sewage to lands for agricultural purposes is deemed an improvement of land, and owners may take advantage of the Improvement of Land Act, 1864.

B.P.(S.)A., 1892.

All sewers and drains within a burgh, with certain exceptions, are vested in the Burgh Commissioners, who may purchase or contract for the use of other sewers, with the proviso that any person who may previously have acquired perpetual right to use any sewer is entitled to use the same or any substituted sewer. The Commissioners may not use private sewers or water-courses without consent, and must form the whole burgh into one drainage district, or into more than one if the sheriff approve. They must construct such main and other sewers as may be necessary for the effectual draining of the burgh, and must provide means for cleansing the sewers. Owners of property must be compensated where the sewers are carried through their lands, and the sewage must be so disposed of as to cause no nuisance. Where works for sewage interception are provided along any stream, river, etc., no person may foul such stream, etc., by sewage. Rubbish of any kind must not, under penalty, be thrown into the channel or on the banks of any water-course within or bounding any burgh. The Commissioners may alter sewers as long as no nuisance is produced in so doing, but must not thereby deprive any one of the use of a sufficient sewer. A penalty is provided for making unauthorised drains communicating with the Commissioners' sewers. No building may be erected over any sewer belonging to the Commissioners, and no structure may be made under the carriage-way of any street without the consent of the Commissioners, nor may it interfere with the sewers.

All sewers and drains, whether public or private, must be trapped and ventilated. The Commissioners may avail themselves of the chimney shafts of factories, etc., for the ventilation of their sewers. It is an offence for any owner or occupier of distilleries, manufactories, or other works, to cause or permit any refuse, refuse water, steam, or other substance, fitted to interrupt the free passage of a sewer, or to be otherwise injurious thereto, or to be injurious to the health of persons living in the vicinity, to enter a public sewer, river, inland loch, public reservoir, or dock. Pools or reservoirs must be constructed as near the works as possible for receiving and depositing such refuse. Owners and occupiers of lands and premises beyond the limits of the burgh may use the burgh sewers by agreement with the Commissioners. With the consent of the Board of Trade, the Commissioners may cause their drainage to discharge below high-water mark.

Drainage of houses.—If any house be insufficiently drained, and if a sewer or the sea be within 100 yds., the Commissioners may make the necessary drains, and recover the cost. No house may be built or rebuilt without drains being constructed, and such drain must open into a sewer if there be one within 100 yds., otherwise into a covered cesspool not under any building. The cesspool must be properly constructed and kept in repair, and must be demolished if a convenient sewer be thereafter provided. House drains must be ventilated and inlets trapped. The owners are responsible for branch drains and cesspools being kept in good order to the satisfaction of the Commissioners.

Inspection of drains and cesspools.—The surveyor may, and when requested by the M.O.H. or S.I., must, inspect any drain, cesspool, or reservoir, and may enter and do any work necessary for inspection. If there be any defect, the Commissioners may order such deficiencies to be made good.

L.G.A., 1889, 1894.

The management of a special drainage district is in the hands of a sub-committee, which, in a landward area, is composed of parish councillors, or of parish councillors and district councillors; and in the case of a drainage district partly within a burgh, of parish councillors, district councillors, and burgh commissioners; and wholly within a burgh, of burgh commissioners alone.

Water Supply.

Acts Concerned.

P.H.(S.)A., 1897; B.P.(S.)A., 1892; Land Clauses Acts, Railway Clauses Consolidation (Scotland) Act, Waterworks Clauses Acts, all incorporated; L.G.(S.)A., 1889, 1894; R.P.P.A., 1876, 1893 (p. 563).

P.H.(S.)A., 1897.

Provisions.—S. 124.—The water supply of burghs is governed by the B.P.(S.)A., except in the case of those burghs which possess local Acts; but the water supply of landward areas is provided for in this Act. This section provides that in both districts the term *land* shall have the significance conferred upon it by the definition on p. 580.

S. 125.—If any occupied house is without a proper supply of wholesome water at or reasonably near the same, the L.A. must require the owner to obtain such supply, and, in case of non-compliance within twelve months after due notice, the L.A. may themselves do the work, and recover the cost in whole or in part from the owner. This does not relieve the L.A. from the duty of providing their district, or any part thereof, with a supply of water where a general scheme for such supply is required, and can be carried out at a reasonable cost.

S. 126.—(1) The L.A. must, if they think it expedient, acquire and provide, or arrange for a supply of water for the domestic use of the inhabitants, and for sanitary and other purposes. For this object the L.A. may construct, purchase, and hire waterworks and all accessories required for taking water from any lake, river, stream, or spring, or they may dig wells, or they may contract or arrange with others to supply water. In carrying out this section, the L.A. may not supersede the rights of any L.A. or company already authorised by Parliament or Provisional Order to supply water within the district, but they may purchase such undertaking. (2) Any surplus water beyond what is required for domestic and sanitary purposes may be supplied by the L.A. to public baths and wash-houses, or for trading or manufacturing, and all other than domestic purposes.

Special provisions are made regarding the charge for such supply. The term *domestic purposes* is not defined in this Act, but in the incorporated Waterworks Clauses Act, water for domestic purposes does not include water-supply for cattle, horses, or for washing carriages where such horses or carriages are kept for sale or hire by a common carrier. Further, it does not include supplies for trade, manufacture, or business, for watering gardens, for fountains, or for any ornamental purpose. (3) The L.A. may maintain and supply with water all existing public waterworks used for the gratuitous supply of water to the inhabitants, or may substitute other works equally convenient. The L.A. may gratuitously supply water for any public baths or wash-houses not established for private profit nor supported out of any rates. (4) The L.A. possess the same powers subject to the same restrictions for carrying water-mains within their district as they possess in respect of sewers.

S. 127.—Any product, washing, or other substance produced in the manufacture of gas, naphtha, vitriol, paraffin, dye-stuffs, or any other deleterious substance, or produced in any trade in which the refuse of such manufactures is used, must not be allowed to enter any stream, reservoir, aqueduct, well or pond, or place for water constructed or used for the supply of water for domestic purposes, nor to enter any pipe or drain communicating therewith. No person may foul such water by any act connected with such manufacture. Any person wilfully fouling, or permitting to be fouled, water used for drinking or domestic purposes is liable to a penalty not exceeding £50.

Ss. 128 and 129.—Penalties due by such manufacturers may be sued for within six months, and a daily penalty may be exacted if the offence continue after twenty-four hours' notice. The penalties are applied to payment of damages caused by the offence.

S. 130.—L.As. may combine as to water supply.

S. 131.—Special water-supply districts similar to special drainage districts may be formed by the L.A. in the same manner as described in s. 122, with the exception of subsection (4), which does not apply.

S. 132 incorporates in this Act those portions of the following Acts which are not inconsistent with the provisions of this Act. These Acts are Waterworks Clauses Act, 1847, with certain exceptions; Waterworks Clauses Act, 1863; Railways Clauses Consolidation (Scotland) Act, 1845 [certain provisions]. The following provisos are enacted:—

(*a*) The L.A. is not obliged to furnish a supply of water to any person for any less sum than 5s. per year. (*b*) No person is entitled to demand such supply of water, or to require the L.A. to lay down communication pipes, unless some pipe of the L.A. shall have been laid within 100 ft. of the house or other premises, or unless the L.A. shall become bound under the Waterworks Clauses Act to cause pipes to be laid down within such distance. (*c*) The water to be supplied by a L.A. need not be constantly laid on under pressure.

B.P.(S.)A., 1892.

Burgh Commissioners, unless other provision has been made by an Act of Parliament, must continue, maintain, and supply with water all existing public cisterns, pumps, wells, etc., used for the gratuitous supply of water to the inhabitants within the burgh, unless the water therein is found to be dangerous or injurious to health, or unfit for dietetic purposes. They may substitute other such works equally convenient, and similarly supply them, and they may supply with water any public baths or wash-houses. They may contract for a supply of water for any period not exceeding three years, and may provide sufficient supplies of water, and erect waterworks. The water so supplied may be constantly laid on at such pressure as will carry the same to the top storey of the highest dwelling-house within the burgh. Burghs having less than 5000 inhabitants may obtain from the sheriff compulsory powers to acquire land for water supply. The service pipes from the mains to the houses are laid at the cost of the owners of the premises, and the Commissioners may require them to be laid to any tenement situated in a street in which the other houses and tenements are so supplied. Wherever practicable, all supplies of water for domestic use shall be taken direct from the main or service pipes, and not from cisterns. No person may use the public water supply for other than domestic and ordinary purposes without special agreement.

The supply of water for domestic and ordinary purposes does not include a supply of water for cattle, or for horses, or for washing carriages, or for steam-engines, or for railway purposes, or for warming or ventilating purposes in public buildings, or for working any machine or apparatus, or for any trade, manufacture, or business whatsoever, or for watering gardens, or for fountains, or for flushing sewers or drains, or for public baths or wash-houses, or for any ornamental purpose.

The Commissioners may provide drinking fountains, and may make by-laws with reference to water supply. The Waterworks Clauses Acts are also incorporated with this Act, but with the proviso that the water to be supplied by the Commissioners need not be constantly laid on under pressure.

L.G.(S.)A., 1889.

The consent of the Standing Joint Committee is required to the outlay of capital upon waterworks.

Part VII. deals with Rating and Borrowing Powers for Sewers, Water Supplies, and Hospitals.

Part VIII. deals with Acquisition of Lands.

Part IX.—LEGAL PROCEEDINGS.

P.H.(S.)A., 1897.

S. 146.—(1) If any nuisance exist upon or in premises possessed or managed by the L.A., or in which the L.A. have an interest, or if the L.A. neglect to perform any duty imposed upon them by this Act, it is competent for any ten resident ratepayers, for a P.C., for the procurator-fiscal of the county, or for the L.G.B. to give written notice to the L.A., and if the matter is not remedied, to appeal to the sheriff. (2) This extends to the L.G.B., to any L.A., or any P.C. the power to petition the sheriff regarding any offensive burial ground under the B.G.(S.)A., 1855.

S. 149.—A L.A. may call upon another L.A. in whose district is situated an offensive, injurious, or dangerous nuisance, to remove such nuisance, if such nuisance be affecting the district of the first-mentioned L.A.

Part X.—PORT SANITARY AUTHORITIES.

Acts Concerned.

P.H.(S.)A., 1897; Merchant Shipping Act, 1894 (p. 537). In addition, Orders and Regulations of L.G.B. (p. 537).

P.H.(S.)A., 1897.

Provisions.—S. 172.—The L.G.B. may, by order, constitute P.L.As. and joint P.L.As., and such orders require to be laid before Parliament. A P.L.A. may be—(1) any L.A. whose district, or part of whose district, forms part of or abuts on any part of a port or the waters of a port; (2) any person having authority in or over such port or any part thereof.

A joint P.L.A. may control the whole or any part of a port, and then consists either—(*a*) of two or more L.As. having jurisdiction within the proposed area or part thereof; or (*b*) representative members of such two or more L.As. A joint P.L.A. may control any two or more ports, and then consists of representative members of all or any L.As. having jurisdiction within such port or any part thereof.

The order constituting a P.L.A., or joint P.L.A., may assign to such authority any powers, duties, etc., under this Act.

A *port* means a port as established for the purposes of the laws relating to the Customs of the United Kingdom.

S. 173.—The P.L.A., or joint P.L.A., has jurisdiction over all waters within limits specified in the order, and also over such district within the jurisdiction of any L.A. as may be specified.

S. 174.—With the sanction of the L.G.B., a P.L.A., or a joint P.L.A., may delegate to any L.A. within or bordering on their district the exercise of their powers.

Part XI.—MISCELLANEOUS.

Provisions as to Ships.

P.H.(S.)A., 1897.

S. 177.—Any ship, lying in any river, harbour, or other water, is subject to the L.A. of the district within, or ex adverso of which, such river, harbour, or other water is situate, and to the sheriff, magistrate, and justices of the peace of the district. The provisions of this Act apply to such ships as if they were houses within such district. Ships belonging to His Majesty or any foreign government are excluded.

S. 178.—Any ship within 3 miles of the coast of Scotland, and not within the district of a L.A., is deemed to be within the district of such L.A. as may be prescribed by the L.G.B., and until such L.A. has been prescribed, then within the district of the L.A. whose district is the nearest adjoining the place where such ship is lying.

S. 179.—The L.A. is entitled to charge for medical services rendered by their M.O.H. in accordance with any regulations of the L.G.B. This charge is payable by the captain on behalf of the owners. It is to be noted that the L.A. may not enforce the payment, but the M.O.H. may bring an action against the person in charge of the ship.

S. 180.—Any L.A. may make by-laws for the removal to any hospital to which such authority are entitled to remove patients, and for keeping in such hospital, so long as may be necessary, any persons, brought within their district by any ship, who are infected with an infectious disease.

Other sections of this Act, also applicable to ships, are ss. 78, 79, 85, and 88. S. 13 of the I.D.N.A. also applies, as does the Merchant Shipping Act.

Provisions as to Buildings.

S. 181.—(1) The L.A. of any district other than a burgh may, subject to the approval of the C.C., make by-laws, for the whole or any part of their district, for regulating the building or rebuilding of houses or buildings, or the use for human habitations of any building not previously so used, or any alteration in the mode of occupancy of any existing house in such a manner as will increase the number of separate houses, in respect to the following matters:—(*a*) The drainage of the subsoil of sites for, and the prevention of dampness in, houses intended for human habitation; (*b*) the structure of walls, foundations, roofs, and chimneys of new buildings in so far as likely to affect human health; (*c*) the ventilation of houses and buildings intended for human habitation; (*d*) the sufficiency of the space about buildings to secure a free circulation of air; (*e*) the construction and arrangement of the drainage of houses and buildings, and of soil pipes and waste pipes, and the construction and position of water-closets, earth-closets, privies, ashpits, cesspools, dungsteads, slop-sinks, and rain-water pipes and rhones; (*f*) the production of suitable building plans in respect of the matters in this section mentioned, and their inspection; (*g*) the intimation, previous to the commencement by the owner or person laying out the work, to the local authority, of the date of the commencement, and for the due inspection, in respect of the matters in this section mentioned, of houses or buildings in process of erection or alteration, and the examination of the drains thereof, and for the pulling down, alteration, or amendment of any work which has been carried out in contravention of the by-laws. (2) In making such by-laws the L.A. shall have regard to the special circumstances of their district, or the part thereof to which such by-laws relate.

S. 182.—(1) A new building must not be erected on any ground which has been filled up with any matter impregnated with fæcal, animal, or vegetable matter, or upon which any such matter has been deposited, unless and until such matter shall have been properly removed by excavation or otherwise, or shall have been rendered or have become innocuous. (2) There is a £5 penalty for contravention, and a daily continuing penalty of 40s.

B.P.(S.)A., 1892.

This Act also relates to buildings, as regards the plans of new buildings, their ventilation, repair, and the provision of sanitary conveniences. It also enacts provisions relating to streets and pavements.

Every person proposing to erect any house or building, or to alter the structure of, and to use for human habitation any existing house or building not previously so used, must petition the Commissioners for a warrant. The petition must disclose full details and be accompanied by plans of the building. The Commissioners must be satisfied that the plans provide suitably for stability, light, ventilation, and other sanitary requirements. Places of public amusement or entertainment, meetings, etc., must be provided with sufficient entrances and exits, and means for protection from fire. No person may erect or alter any house or building without the prior sanction of the Commissioners. Every dwelling-house must have its rooms sufficiently lighted and ventilated from a street or open space directly attached to the building, and equal to three-fourths of the area covered by the building. No erections are allowed on such space, except sanitary and other conveniences. In tenement houses, not more than twelve dwelling-houses may open from one common inside stair, and not more than twenty-four where there is an outside stair with balconies. No such stair may be less than 4 ft. in width. Habitable rooms on the ground-floor of dwelling-houses must not be less than 9 ft. 6 in. in height in any part. Other habitable rooms, except attics, must be 9 ft. in height, and every habitable attic room must be 8 ft. in height through not less than one-third the area of the room, and must at no part be less than 3 ft. Every habitable room must have at least one window, and the total area of glass in the windows, clear of frame and sash, must be at least one-tenth of the area of the room. The top of at least one window must not be less than 7 ft. 6 in. above the floor. The upper half of sash windows must be made to open the full width, and in a casement window one-half at least should be made to open. No pipe for conveying smoke or heated air may be fixed in any new building otherwise than in the wall thereof, and unless approved by the Commissioners. There are certain restrictions as to the position of steam pipes and funnels for conveying smoke. No person may erect any building upon any ground which shall have been filled up with any material impregnated with fæcal matter, or with any animal, or vegetable, or mineral, or other offensive matter, unless the M.O.H. or S.I. certify that proper precautions have been taken to obviate any prejudice to the health of any resident or neighbouring residents. New houses must be surveyed before occupation.

Rules for New Buildings.

1. The site of the intended building shall be dug out to such depth as shall be necessary, in the opinion of the Commissioners, for the removal therefrom of soil or refuse; and it shall not be lawful for any person to build upon any site until such soil or refuse is so removed.

2. The walls of every new building to be used as a dwelling-house shall have a damp course of durable material, impervious to moisture; the damp course for external walls to be at the level of the ground directly abutting upon the external wall, or at such other level as the Commissioners shall order. Party walls to have the damp course at a level of not less than the under side of the joisting of the lowest floor; and where, in the judgment of the Commissioners, the nature of the soil or subsoil requires it, the whole internal area of the site shall be covered with a layer of asphalt, cement, concrete, or suitable material to their satisfaction.

3. The outer walls and the party walls or separate side or end walls, and the joisting and principal timber and ironwork, shall be of sufficient strength and stability.

4. There shall be to the satisfaction of the Commissioners sufficient ashpit and water-closet or privy accommodation in connection with the building.

5. The plan of the building shall not contemplate the raising or lowering of any article from windows or openings towards any public streets by hoists or other appliances outside the building line.

6. All party walls and gables shall be built solid, except at vents, fireplaces, presses, and where the Commissioners may allow them to be built otherwise.

7. All external walls, party walls, passage walls, partition walls dividing separate houses, staircases, stairs, and landings shall be constructed with incombustible materials, and all party walls shall be carried through and above the roof to form a parapet. The parapet to be finished on top with a cope, and the height of parapet to be not less than 12 in., measured at right angles with the slope of the roof, above the covering of the roof of the highest building to which such party wall belongs.

8. All walls of dwelling-houses shall be so constructed as to prevent damp.

9. The mortar to be used in the construction of new or altered buildings shall be composed of fresh burnt lime and clean sharp pit sand, grit or ground bricks, or freestone shivers, without earthy matter, and no sea or ballast sand shall be used.

10. The joists under every hearth shall be bridled, and, where practicable, the hearth shall be supported by a brick arch or concrete under its whole area, or to be otherwise constructed or supported as the Commissioners may direct. Every fireplace shall have jambs and lintels or arches of incombustible material projecting at least to the flush of the plaster work. No timber joist, beam, or safety lintel shall be inserted into a wall nearer to the fireplace or vents, where practicable, than 12 in.

11. Every building shall have rhones, gutters, or spouts along the eaves thereof, with down spouts and perforated gratings, to carry all water falling on the roof thereon to the drains.

12. No part of a built chimney or flue must be less than 9 in. by 9 in., and no part of a wall on the outside or house side of the chimney to be of less

thickness than 9 in. Every chimney head shall have a stone cope, into which chimney cans can with safety be inserted, and such chimney cans shall be sufficiently guarded.

13. The floors between each flat of a tenement shall be deafened.

14. All apartments in every dwelling-house shall be plastered with three coats plaster.

15. All plumber work connected with sanitary arrangements and house drains shall be ventilated, trapped, and otherwise constructed and tested to the satisfaction of the Commissioners.

16. In ground-floors where the space from surface has to be filled up to level of floors, the same shall be filled up, subject always to sufficient space being left for ventilation, with dry stone shivers or such other materials as the Commissioners may appoint.

17. All private courts, common passages, and common areas (other than bleaching greens) shall be paved with natural or artificial stone, or such other material as the Commissioners shall approve, and be provided with proper and sufficient means for taking off the surface water.

18. No external covering of any roof shall be constructed of combustible materials ; and it shall not be lawful for the owner of any building having, at the date when this Act comes into operation, a roof covered with thatch, or other combustible material, and contiguous to or adjoining to any other building, to suffer such covering to such roof to remain for a longer period than seven years thereafter, unless with the consent in writing of the Commissioners. And every person who shall suffer the covering of any roof to continue, contrary to the provisions herein contained, and who shall not remove or alter the same within one month after notice given to him for that purpose by the Commissioners, shall be liable to a penalty not exceeding £1 for every day that such building or covering to such roof shall so continue.

Any person failing to comply with any of these conditions in a good and sufficient manner shall be guilty of an offence, and be liable for each offence to a penalty not exceeding £5.

Sanitary Conveniences.

The Commissioners may require owners of premises to introduce water, to fit up a sink for foul water, and a water-closet, for each part of a house occupied by a separate family. In tenements, a sufficient number of water-closets for the separate use of each sex may be required to be constructed on each flat. The occupier of a house is liable to penalty if ashes or other matters calculated to choke a cesspool or soil pipe are allowed to enter it. The situation, dimensions, materials, and construction of every water-closet, or earth-closet and privy, are subject to the approval of the Commissioners, and every such convenience must have one of its sides an external wall with a window therein having an area of at least 6 superficial ft., one-half of which shall be made to open. The cistern which supplies the water-closet must have no communication with the water-closet, except the service pipe. A cesspool must be avoided wherever possible, but if present, must be made water-tight, be covered, and must be freely ventilated by an inlet and outlet shaft. The outlet shaft may be upon the communicating drain.

Ashpits must be of sufficient size, and be constructed and placed as approved by the Commissioners. Owners may be required to remove any privy, ashpit, cesspool, or midden adjacent to any room, and if certified by the M.O.H. to be prejudicial to health, defective in construction, without drainage, in bad repair, or so situated that the removal of filth or refuse therefrom is prejudicial to health, the owner may be required to remedy the same, or to convert the privy into a water-closet or earth-closet, or the Commissioners may order the removal of such privy, ashpit, or cesspool.

No new street must be less than 36 ft. wide for the carriage-way and foot-pavement, and no dwelling-house may in height exceed by more than one-fourth the width of such street.

APPENDIX A

TABLES FOR THE USE OF MEDICAL OFFICERS OF HEALTH, AS ISSUED BY THE LOCAL GOVERNMENT BOARD.

TABLE I.

NAME OF DISTRICT.................................

FOR WHOLE DISTRICT.

Year.	Population Estimated to Middle of each Year.	Births.		Total Deaths Registered in the District.				Total Deaths in Public Institutions in the District.	Deaths of Non-residents Registered in Public Institutions in the District.	Deaths of Residents Registered in Public Institutions beyond the District.	Net Deaths at all Ages belonging to the District.	
				Under 1 Year of Age.		At all Ages.						
		Number.	Rate.[1]	Number.	Rate per 1000 Births Registered.	Number.	Rate.[1]				Number.	Rate.[1]
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
190 .												
190 .												
190 .												
190 .												
190 .												
190 .												
190 .												
190 .												
190 .												
190 .												
Averages for ten years 190 -190 .												
190 .												

[1] Rates calculated per 1000 of estimated population.

Area of district in acres (exclusive of area covered by water)	Total population at all ages . . No. of inhabited houses . . Average number of persons per house	Census of............

Notes to Table I.

The deaths to be included in column 7 of this table are the whole of those registered during the year as having actually occurred within the district or division. The deaths to be included in column 12 are the number in column 7, corrected by the subtraction of the number in column 10 and the addition of the number in column 11.

By the term "non-residents" is meant persons brought into the district on account of sickness or infirmity, and dying in public institutions there; and by the term "residents" is meant persons who have been taken out of the district on account of sickness or infirmity, and have died in public institutions elsewhere.

The "public institutions" to be taken into account for the purposes of these tables are those into which persons are habitually received on account of sickness or infirmity, such as hospitals, workhouses, and lunatic asylums. A list of the institutions in respect of the deaths in which corrections have been made should be given on the back of this table.

[The following table for deaths in institutions forms part of Table I., being on the back of the copy issued by the Local Government Board.]

I. Institutions within the District receiving Sick and Infirm Persons from outside the District.	II. Institutions outside the District receiving Sick and Infirm Persons from the District.	III.[1] Other Institutions, the Deaths in which have been distributed among the several Localities in the District.

[1] Column III. is for institutions within the district receiving cases therefrom only—*e.g.*, the workhouse of a Union co-terminous with a single sanitary district having several "localities," as in many rural districts and some large towns.

TABLE II.

VITAL STATISTICS OF SEPARATE LOCALITIES IN 190— AND PREVIOUS YEARS.

Name of District..............................

Names of Localities	1.				2.				3.				4.				5.			
Year.	Population estimated to Middle of each Year.	Births registered.	Deaths at all Ages.	Deaths under 1 Year.	Population estimated to Middle of each Year.	Births registered.	Deaths at all Ages.	Deaths under 1 Year.	Population estimated to Middle of each Year.	Births registered.	Deaths at all Ages.	Deaths under 1 Year.	Population estimated to Middle of each Year.	Births registered.	Deaths at all Ages.	Deaths under 1 Year.	Population estimated to Middle of each Year.	Births registered.	Deaths at all Ages.	Deaths under 1 Year.
Column	*a*	*b*	*c*	*d*	*a*	*b*	*c*	*d*	*a*	*b*	*c*	*d*	*a*	*b*	*c*	*d*	*a*	*b*	*c*	*d*
Averages of years.... to....																				

NOTES TO TABLE II.

(*a*) The separate localities adopted for this table should be areas of which the populations are obtainable from the census returns, such as wards, parishes or groups of parishes, or registration sub-districts. Block 1 may, if desired, be used for the whole district, and blocks 2, 3, etc., for the several localities. In small districts without recognised divisions of known population this table need not be filled up.

(*b*) Deaths of residents occurring in public institutions beyond the district are to be included in sub-columns *c* of this table, and those of non-residents registered in public institutions in the district excluded. (See Note on Table I. as to meaning of terms "resident" and "non-resident.")

(*c*) Deaths of residents occurring in public institutions, whether within or without the district, are to be allotted to the respective localities according to the addresses of the deceased.

(*d*) Care should be taken that the gross totals of the several columns in this table respectively equal the corresponding totals for the whole district in Tables I. and IV. Thus, the totals of sub-columns *a*, *b*, and *c* should agree with the figures for the year in the columns 2, 3, and 12 respectively of Table I.; the gross total of the sub-columns *c* should agree with the total of column 2 in Table IV.; and the gross total of sub-columns *d* with the figure in column 3 in Table IV.

TABLE III.

CASES OF INFECTIOUS DISEASE NOTIFIED DURING THE YEAR 190—.

NAME OF DISTRICT.............................

	Cases notified in Whole District.							Total Cases notified in each Locality.						No. of Cases removed to Hospital from each Locality					
	At all Ages.	At Ages [2]—Years.																	
		Under 1.	1–5.	5–15.	15–25.	25–65.	65 and upwards.	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
Smallpox .																			
Cholera .																			
Diphtheria .																			
Membranous croup .																			
Erysipelas .																			
Scarlet fever																			
Typhus ,, .																			
Enteric ,, .																			
Relapsing,, .																			
Continued,, .																			
Puerperal,, .																			
Plague .																			
[1]																			
Totals .																			

[1] This space may be used for record of other disease, the notification (compulsory or voluntary) of which is in force in the district.

[2] The age columns for notifications should be filled up in all cases where the Medical Officer of Health, by inquiry or otherwise, has obtained the necessary information.

NOTES TO TABLE III.

The localities adopted for this table should be the same as those in Tables II. and IV.

State the name of the isolation hospital, if any, to which residents in the district, suffering from infectious disease, are usually sent. Mark (H) the locality in which it is situated, or if not within the district, state where it is situated, and in what district.

[Reference should be made to the memorandum issued by the Board as to reports of medical officers of health for guidance in completing this table.]

TABLE IV.

CAUSES OF, AND AGES AT, DEATH DURING YEAR.........

NAME OF DISTRICT.................................

Causes of Death.	Deaths in or belonging to Whole District at Subjoined Ages.							Deaths in or belonging to Localities at all Ages.							Total Deaths in Public Institutions in the District.
	All Ages.	Under 1.	1-5.	5-15.	15-25.	25-65.	65 and upwards.								
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Smallpox . . .															
Measles . . .															
Scarlet fever . .															
Whooping-cough . .															
Diphtheria and membranous croup . .															
Croup															
Fever: Typhus . .															
Fever: Enteric . .															
Fever: Other continued															
Epidemic Influenza .															
Cholera . . .															
Plague . . .															
Diarrhœa (see note) .															
Enteritis (see note) .															
Puerperal fever . .															
Erysipelas . . .															
Other septic diseases .															
Phthisis . . .															
Other tubercular diseases . . .															
Cancer, malignant disease															
Bronchitis . . .															
Pneumonia . . .															
Pleurisy . . .															
Other diseases of respiratory organs .															
Alcoholism / Cirrhosis of liver .															
Venereal diseases. .															
Premature birth . .															
Diseases of parturition and accidents . .															
Heart diseases . .															
Accidents . . .															
Suicides . . .															
....															
....															
....															
....															
....															
....															
All other causes . .															
All causes . .															

Notes to Table IV.

(*a*) In this table all deaths of "residents" occurring in public institutions, whether within or without the district, are to be included with the other deaths in the columns for the several age-groups (columns 2–8). They are also, in columns 9–15, to be included among the deaths in their respective "localities" according to the previous addresses of the deceased as given by the registrars. Deaths of "non-residents" occurring in public institutions in the district are in like manner to be excluded from columns 2–8 and 9–15 of this table.

(*b*) *See* notes on Table I. as to the meaning of "residents" and "non-residents," and as to the "public institutions" to be taken into account for the purposes of these tables. The "localities" should be the same as those in Tables II. and III.

(*c*) All deaths occurring in public institutions situated within the district, whether of "residents" or of "non-residents," are, in addition to being dealt with as in note (*a*), to be entered in the last column of this table. The total number in this column should equal the figures for the year in column 9, Table I.

(*d*) The total deaths in the several "localities" in columns 9–15 of this table should equal those for the year in the same localities in Table II., sub-columns *c*. The total deaths at all ages in column 2 of this table should equal the gross total of columns 9–15, and the figures for the year in column 12 of Table I.

(*e*) Under the heading of "diarrhœa" are to be included deaths certified as from diarrhœa, alone or in combination with some other cause of ill-defined nature; and also deaths certified as from epidemic enteritis; zymotic enteritis; epidemic diarrhœa; summer diarrhœa; dysentery and dysenteric diarrhœa; choleraic diarrhœa, cholera, cholera nostras (in the absence of Asiatic cholera).

Under the heading of "enteritis" are to be included those certified as from gastro-enteritis, muco-enteritis, and gastric catarrh, unless from information obtained by inquiry from the certifying practitioner or otherwise, the medical officer of health should have reason for including such deaths, especially those of infants, under the specific term "diarrhœa."

Deaths from diarrhœa secondary to some other well-defined disease should be included under the latter.

The following schedules issued as patterns by the Incorporated Society of Medical Officers of Health are here included as likely to prove useful.

[Table V.

TABLE V.

COMPARISON OF PREVALENCE OF SICKNESS AND DEATH FROM INFECTIOUS DISEASES.

(Rates calculated per 1000 persons, on the population estimated to the middle of each year.)

Year.	Smallpox.		Cholera.		Erysipelas.		Diphtheria, Membranous Croup.		Scarlet Fever.		Typhus Fever.		Enteric and Continued Fevers.		Relapsing Fever.		Puerperal Fever.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
1890 . . .																		
1891 . . .																		
1892 . . .																		
1893 . . .																		
1894 . . .																		
1895 . . .																		
1896 . . .																		
1897 . . .																		
1898 . . .																		
1899 . . .																		
1900 . . .																		

Annual rates for a series of years are recommended in preference to average rates. The rates will be based on statistics for "residents" only.

TABLE VI.

SHOWING CAUSES OF DEATHS OF INHABITANTS OF DISTRICT OF .... DURING THE YEAR 19...

Causes of Death.	Ages at Death.															
	0–	1–	5–	10–	15–	20–	25–	35–	45–	55–	65–	75–	85–	All Ages.		
														M.	F.	P.
Smallpox—																
(*a*) Vaccinated . .																
(*b*) Unvaccinated .																
(*c*) No statement .																
Measles																
Scarlet Fever . .																
Typhus Fever . .																
Epidemic Influenza .																
Whooping-cough . .																
Diphtheria, Membranous croup . . .																
Enteric Fever . .																
Asiatic Cholera . .																
Diarrhœa, Dysentery .																
Epidemic or Zymotic Enteritis																
Other allied diseases: Plague . .																
....																
....																
....																

The table will be limited to "residents" only. M = Males. F = Females. P = Persons.

TABLE VI.—*continued.*

Causes of Death.	Ages at Death.															
	0–	1–	5–	10–	15–	20–	25–	35–	45–	55–	65–	75–	85–	All Ages.		
														M.	F.	P.
Hydrophobia																
Glanders, Farcy																
Tetanus																
Anthrax, Splenic Fever																
Cowpox, Effects of Vaccination																
Syphilis																
Gonorrhœa																
Phagedæna																
Erysipelas																
Puerperal Fever																
Pyæmia, Septicæmia																
Infective Endocarditis																
Other allied diseases: Carbuncle																
....																
....																
....																
Malarial Fever																
Rheumatic Fever																
Rheumatism of the heart																
Tuberculosis of all forms																
....																
....																
....																
....																
....																
....																
Other infective diseases: Leprosy																
Malta Fever																
Beri-beri																
....																
Thrush																
Actinomycosis																
Hydatid Diseases																
Other parasitic diseases: Filaria																
....																
....																
....																
Scurvy																
Other diseases due to altered food: Ergotism																
....																
....																
....																
....																
....																
Acute Alcoholism																
Chronic Alcoholism																
Chronic Industrial Poisoning																
(Then follow 124 other causes.)																

The table will be limited to "residents" only. M = Males. F = Females. P = Persons.

FORM FOR INTERCHANGE OF INTIMATION OF DEATHS OF "NON-RESIDENTS" AS RECOMMENDED BY THE INCORPORATED SOCIETY OF MEDICAL OFFICERS OF HEALTH.

To the Medical Officer of Health

of...............................

Dear Sir,

For your information, I forward you particulars of the under-mentioned death of a resident of your district, which has been reported to me by the local registrar as having occurred in a public institution in this district.

I shall be obliged if you will forward me similar information of any deaths of residents of this district taking place in public institutions within the area under your supervision.

I am, Dear Sir,

Yours faithfully,

Medical Officer of Health.

Date of death...

Where died...

Home address...

Deceased's name...

Sex............................ *Age*..........................

Civil status...

Cause of death...

....

....

Certified or inquest held.

RULES AS TO CLASSIFICATION OF CAUSES OF DEATH.

With the following exceptions, the general rule should be to select from several diseases mentioned in the certificate *the disease of the longest duration.* In the event of no duration being specified, the disease standing first in order should be assumed to be the disease of longest duration.

EXCEPTIONS TO THE ABOVE RULE.

Any one of the *chief infective diseases* should be selected in preference to any other cause of death. If two infective diseases in succession be specified, the disease of *longer* duration should be selected.

Thus, scarlet fever should be selected in preference to broncho-pneumonia, and phthisis in preference to bronchitis.

Definite diseases, ordinarily known as *constitutional diseases,* should have preference over those known as local diseases.

Thus, cancer should be selected in preference to pneumonia, and diabetes in preference to heart disease.

When *apoplexy* occurs in conjunction with definite *disease of the heart or kidneys*, the heart disease or the kidney disease, as the case may be, should be preferred.

When *hemiplegia* is mentioned in conjunction with *embolism*, the *embolism* should be selected.

When *embolism* occurs in connection with *childbirth*, the death should be referred to *accidents of childbirth*.

Diarrhœa.—Under this heading are to be scheduled deaths from *diarrhœa*, *choleraic diarrhœa* (*cholera nostras*), and *intestinal* or *enteric catarrh*. Deaths due to "diarrhœa" occurring in the course of well-defined diseases, such as "tuberculosis," "cancer," etc., are not to be included. When such terms as "gastric catarrh," "gastro-enteritis," "muco-enteritis," etc., are used in death certificates, inquiries should be made of the certifying practitioners, and if they are of opinion that the fatal illness was of the nature of *epidemic* or *zymotic enteritis*, the deaths should be scheduled under that heading, otherwise under *enteritis*.

A separate heading *epidemic* or *zymotic* enteritis is provided, on the ground that this cause of death has only recently been scheduled by the Registrar-General as *diarrhœa*. By retaining the separate schedule for a few years, it will be possible to ascertain the number of deaths which are transferred from "enteritis" or "gastro-enteritis" to *diarrhœa*.

In calculating the death-rate from "diarrhœa," deaths certified as due to *diarrhœa*, either alone or coupled with some ill-defined cause (such as "atrophy," "debility," "marasmus," "thrush," "convulsions," "teething," "old age," or "senile decay"), *epidemic* or *summer diarrhœa*, *epidemic* or *zymotic enteritis*, *intestinal* or *enteric catarrh*, *gastro-intestinal* or *gastro-enteric* catarrh, *dysentery* or *dysenteric diarrhœa*, *cholera* (not being "Asiatic cholera"), *cholera nostras*, *cholera infantum*, and *choleraic diarrhœa* should be included.

The following miscellaneous examples are given as indicating the method of classification in cases of difficulty that frequently arise:—

Causes of Death in order given in Death Certificate.	To be Classified under
Whooping-cough, broncho-pneumonia, scarlet fever.	Whooping-cough, if of longer duration than scarlet fever.
Scarlet fever six months, otitis media, abscess of brain.	Scarlet fever.
Laryngeal and pulmonary phthisis.	Phthisis.
Pneumonia, old age.	Pneumonia.
Old age, bronchitis.	Bronchitis.
Phthisis, diabetes mellitus.	Select disease of longest duration.
Diphtheria nine months, paralysis.	Diphtheria.
Puerperal perimetritis.	Puerperal fever.
Cerebral embolism.	Embolism.
Spasmodic croup.	Laryngismus stridulus.
Acute hydrocephalus.	Tubercular meningitis.
Bronchitis, phthisis.	Phthisis.

APPENDIX B

COTTON CLOTH FACTORIES.

TABLE.

MAXIMUM LIMITS OF HUMIDITY OF THE ATMOSPHERE AT GIVEN TEMPERATURES.

I.	II.	III.	IV.
Grains of Vapour per Cubic Foot of Air.	Dry Bulb Thermometer Readings. Degrees Fahr.	Wet Bulb Thermometer Readings. Degrees Fahr.	Percentage of Humidity. Saturation = 100.
1·9	35	33	80
2·0	36	34	82
2·1	37	35	83
2·2	38	36	83
2·3	39	37	84
2·4	40	38	84
2·5	41	39	84
2·6	42	40	85
2·7	43	41	84
2·8	44	42	84
2·9	45	43	85
3·1	46	44	86
3·2	47	45	86
3·3	48	46	86
3·4	49	47	86
3·5	50	48	86
3·6	51	49	86
3·8	52	50	86
3·9	53	51	86
4·1	54	52	86
4·2	55	53	87
4·4	56	54	87
4·5	57	55	87
4·7	58	56	87
4·9	59	57	88
5·1	60	58	88
5·2	61	59	88
5·4	62	60	88
5·6	63	61	88
5·8	64	62	88

TABLE—*continued.*

I.	II.	III.	IV.
Grains of Vapour per Cubic Foot of Air.	Dry Bulb Thermometer Readings. Degrees Fahr.	Wet Bulb Thermometer Readings. Degrees Fahr.	Percentage of Humidity. Saturation = 100.
6·0	65	63	88
6·2	66	64	88
6·4	67	65	88
6·6	68	66	88
6·9	69	67	88
7·1	70	68	88
7·1	71	68·5	85·5
7·1	72	69	84
7·4	73	70	84
7·4	74	70·5	81·5
7·65	75	71·5	81·5
7·7	76	72	79
8·0	77	73	79
8·0	78	73·5	77
8·25	79	74·5	77·5
8·55	80	75·5	77·5
8·6	81	76	76
8·65	82	76·5	74
8·85	83	77·5	74
8·9	84	78	72
9·2	85	79	72
9·5	86	80	72
9·55	87	80·5	71
9·9	88	81·5	71
10·25	89	82·5	71
10·3	90	83	69
10·35	91	83·5	68
10·7	92	84·5	68
11·0	93	85·5	68
11·1	94	86	66
11·5	95	87	66
11·8	96	88	66
11·9	97	88·5	65·5
12·0	98	89	64
12·3	99	90	64
12·7	100	91	64

APPENDIX C

TABLE OF EQUIVALENTS

LENGTH.

One inch	= 2·54 centimetres.
,, foot	= 30·5 ,,
,, yard	= ·914 metre = $\frac{1}{1760}$ mile.
,, mile	= 1·61 kilometre.
,, geographical or nautical mile . .	= 6080 feet = 1·151 statute miles = $\frac{1}{60}$ degree.
,, millimetre	= ·001 metre = ·03937 inch.
,, centimetre	= ·01 ,, = ·3937 ,,
,, metre	= 39·37 inches = 3·28 feet = 1·0936 yards.
,, kilometre	= 1000 metres = ·6214 mile.

To express	inches	as millimetres	multiply by	25·4.
,,	,,	,, centimetres	,,	2·54.
,,	,,	,, metres	,,	·0254.
,,	millimetres	,, inches	,,	·03937.
,,	centimetres	,, ,,	,,	·3937.
,,	metres	,, ,,	,,	39·37.
,,	,,	,, feet	,,	3·28.
,,	feet	,, miles	,,	·00019.
,,	,,	,, centimetres	,,	30·5.
,,	,,	,, metres	,,	·305.
,,	yards	,, miles	,,	·00057.
,,	,,	,, centimetres	,,	91·44.
,,	miles	,, kilometres	,,	·6214.
,,	kilometres	,, miles	,,	1·6.

WEIGHT.

One grain	= ·0648 gramme.
,, ounce (avoir.) . .	= 437·5 grains = 16 drachms = 28·35 grammes.
,, pound (,,) . .	= 7000 grains = 453·6 grammes.
,, ton	= 2240 lb. = 20 cwt. = 1016·0475 kilogrammes.
,, gramme . . .	= 15·432 grains = ·0353 ounce (avoir.) = ·0022 lb. (avoir.).
,, kilogramme . . .	= 15432 grains = 1000 grammes.
,, gallon (water) . .	= 10 lb. = 70,000 grains.
,, cubic centimetre (water)	= 1 gramme.
,, cubic foot (water) . .	= 62·5 lb.

To express grains	as grammes	multiply by	·0648.
,, ounces	,, ,,	,,	28·35.
,, pounds	,, ,,	,,	453·6.
,, tons	,, pounds	,,	2240.
,, ,,	,, kilogrammes	,,	1016·0475.
,, grammes	,, grains	,,	15·432.
,, ,,	,, ounces	,,	·0353.
,, ,,	,, pounds	,,	·0022.
,, kilogrammes	,, ,,	,,	2·204.
,, ,,	,, tons	,,	·00098.

VOLUME.

One pint . . . = ·57 litre = 20 fluid ounces = ·02 cubic foot = $\frac{1}{8}$ gallon.
,, gallon . . = 4·54 litres = ·16 cubic foot = 277·25 cubic inches.
,, fluid ounce . . = 28·35 cubic centimetres and 1·728 cubic inches.
,, cubic inch . . = ·0058 cubic foot.
,, ,, foot . . = 1728 cubic inches = 6·25 gallons = 28·3 litres = 1000 ounces.
,, litre . . . = 1000 cubic centimetres = 35·3 fluid ounces = 1·76 pint = ·22 gallon = 61·06 cubic inches.
,, cubic centimetre . = ·061 cubic inch.
,, cubic metre . . = 35·316 cubic feet.

To express pints	as cubic inches	multiply by	34·65.
,, ,,	,, cubic centimetres	,,	568·1818.
,, ,,	,, litres	,,	·57.
,, gallons	,, cubic feet	,,	·1605.
,, ,,	,, litres	,,	4·5434.
,, fluid ounces	,, cubic inches	,,	1·72.
,, ,,	,, cubic centimetres	,,	28·35.
,, cubic inches	,, pints	,,	·0288.
,, ,,	,, gallons	,,	·003607.
,, ,,	,, fluid ounces	,,	·577.
,, ,,	,, cubic centimetres	,,	16·386.
,, cubic feet	,, gallons	,,	6·25.
,, ,,	,, litres	,,	28·3.
,, ,,	,, cubic metres	,,	·0283.
,, litres	,, pints	,,	1·76.
,, ,,	,, gallons	,,	·22.
,, ,,	,, fluid ounces	,,	35·3.
,, ,,	,, cubic feet	,,	·354.
,, ,,	,, cubic inches	,,	61·06.
,, cubic centimetres	,, ,,	,,	·061.
,, cubic metres	,, cubic feet	,,	35·3.

AREA.

One acre . . . = 4840 square yards = 4 roods = 160 poles = $\frac{1}{640}$ square mile.
,, square mile . . = 640 acres.
,, square foot . . = 144 square inches.
,, square yard . . = 9 square feet.
,, square metre . . = 10·764 square feet.

To express square feet	as square metres	multiply by	·0924.
,, ,,	,, square yards	,,	·111.
,, square metres	,, square feet	,,	10·764.

Water pressure.—A column of water 2·305 ft. in height, and having a sectional area of 1 square in., exercises a pressure of 1 lb. per square in., and therefore a column 33·8835 ft. exerts a pressure of 14·7 lb. per square in. = atmospheric pressure.

Water supply.—1 in. of rainfall is equivalent to 101 tons per acre, or 22,624 gallons.

TABLE OF TEMPERATURES CORRESPONDING TO STEAM-PRESSURES.

Temperatures.		Steam-Pressure.
F.	C.	lb.
212°	100°	0
228°	109°	5
240°	115°·5	10
251°	121°·5	15
260°	126°·5	20
287°	141°·5	40

Pipe capacities.—To find the capacity of any circular pipe, square its diameter in inches, divide by 10, and the result is the number of gallons which 1 yd. of the pipe will hold when filled.

Thus 1 yd. of 4-in. pipe holds 1·6 gallons.
,, 6 ,, ,, 3·6 ,,
, 9 ,, ,, 8·1 ,,

APPENDIX D

BACTERIOLOGICAL EXAMINATION OF WATER, pp. 205, 206.

Cholera vibrios can be more readily demonstrated in an infected water if a solution of alkaline peptone and common salt be added to it, and the whole placed in the thermostat. The motile vibrios make their way to the surface of the liquid, and develop more speedily and in greater quantity than do other organisms present. The same to a lesser extent holds good in the case of the *B. typhosus*, but, in addition, carbolic acid should be previously added to inhibit the development of other bacterial forms.

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