polygonal hospitals of one story, well raised from the ground on posts, destroyed after one generation's use, and transferred elsewhere for the next. The principle also relieves us from the necessity of providing for posterity.

These are strong arguments, but undoubtedly the strongest against costly permanent hospitals is the undoubted fact that in half a century ours will be thought of as we now think of the old Hôtel Dieu in Paris.

Should Portland cement concrete slabs prove to be tolerably non-retentive of infectious matter, Lascelles' construction seems the best of those mentioned, but otherwise galvanised iron buildings lined with Willesden paper, which could have their linings burnt and renewed, and the iron flamed every few years, would prevail in Class II.

In this class of hospital a greater number than six in each polygon should probably be attempted, but for large numbers, with a central administration and schools, the general scheme should be identical with that mentioned for Class I.

It is for the public to choose whether they will exercise their benevolence in this manner, which *caeteris paribus* would afford more relief than the present system, or in raising monuments which, however in accordance with the most advanced scientific views, may yet, for aught we know, propagate disease, and will most assuredly be despised by posterity.

Sir Robert Rawlinson, C.B. (the President of the Congress), said this was one of the best papers he had listened to, and he wished the promoters the best possible success. All his sympathies were with cheap temporary hospitals. Here was a proposal by which a man could have restoration to health in a hospital where the cost would only be 1s. each bed per week.

SECTION III.

CHEMISTRY, METEOROLOGY AND GEOLOGY.

ADDRESS

By Charles A. Cameron, F.R.C.S.I., C.S.S.Camb.

PRESIDENT OF THE SECTION.

That abnormal food is a factor in the production of disease and death in man is a fact acknowledged from time immemorial. The divinely inspired laws promulgated by Moses, direct that the flesh of animals that have died from disease shall not be used as food. They also prohibit the use of blood as food—a remarkable prohibition, when it is considered that it is chiefly in the blood that the virus of so many dangerous diseases circulates. The writers of the Babylonian Talmud make frequent references to the subject of diseased food, and clearly recognize the difference between the flesh of an animal affected with a specific disease, and that of an animal injured by purely accidental causes.

It is only within a very recent period that the particular causes which render both animal and vegetable food unwholesome or actually poisonous have been scientifically investigated. The information gained, though a substantial addition to our knowledge of the ætiology of disease, is still, in many respects, very imperfect. The further elucidation of this interesting subject offers a wide field of enquiry to the microscopist, the chemist, the pathologist, and the biologist.

For the purposes of this address I shall arrange diseased and otherwise unsound food into five classes:—

1st. Vegetable food infested by fungi and other parasities, chiefly miscroscopic.

2nd. Animal food containing entozoa, or internal parasities.

3rd. Animal food containing micro-organisms endowed with virulent properties.

4th. Animal and vegetable foods containing alkaloids generated during putrefaction.

5th. The flesh of animals affected by specific diseases, the various *materies morbi* of which have not been isolated.

POISONOUS MOULDS.

Ergot, a disease affecting the seeds of the grasses, and especially of rye, is caused by a minute organism, placed by Link and Berkeley amongst the species of fungi included in the genus *Oidium*. The ergotized grain is very dark, sometimes quite black. These fungi in large doses are poisonous. They cause gangrene of various parts of the body, and even sloughing off of the extremities has been occasioned by them. Some years ago I found that the grasses in a large field near Navan, county of Meath, were peculiarly affected with ergot. The animals that grazed in the field lost their horns and hoofs. Many localized epidemics of gangrenous disease have been caused by the use of ergotized grain.

The genus Oidium includes a species which has often almost annihilated the wine crops of France and other countries.

The moulds, or minute fungi which are developed in bread and other vegetable foods are occasionally poisonous. Five species of moulds have been observed on bread, namely, Mucor mucedo, Penicillium glaucum, Aspergillus glaucus, Ascophora nigricans, and Oidium aurantiacum. Of these M. Mégnin considers the last named the most poisonous.* This author cites cases showing the poisonous qualities of mouldy bread.

In Sheffield in 1879 eight persons were poisoned by eating puddings chiefly prepared in an "eating house" from bread crusts, the accumulation of weeks, and which undoubtedly must have been mouldy. Two of the affected persons died. The scientific evidence produced at the inquests negatived the presence of ordinary poisons in the food. In the *Veterinarian* for May, 1878, I published an account of the deaths of a large number of sheep and oxen which I clearly proved to have been caused by eating mouldy food. In the *Dublin Journal of Medical Science* for February, 1879, I have recorded several cases of death and illness in man caused by mouldy food, which I had personally investigated.

The presence of fungi, and probably of algæ, in potable water,

* *Revue d'Hygiene*, Paris, 20th June, 1881.

occasionally causes the latter to have poisonous properties. Dr. Holdefleiss, in Biedermann's "Centrallblatt" for 1879, insists strongly on the poisonous nature of water in which the colourless algæ occur.

It has been noticed that lake and pond waters often acquire a green colour, which passes away after a few days. This colour is generally due to the development of immense numbers of oscillaria, *Englena Viridis*, &c. These coloured waters frequently are sufficiently toxic to kill all the fish in them. Some time ago I had a water of this kind, which on being preserved for some weeks in a glass vessel, passed from a green to a magnificent red hue. The change was caused by the oxidation of the chlorophyll formed by the algæ.

A specimen of bluish-green water, from Lough Derg on the Shannon, was sent to me for examination in June last. The coloured water rather suddenly appeared in a creek of the lake, and geese and ducks belonging to several persons were poisoned by drinking. In this case the colour appeared to be due not so much to algæ as to pigment forming micrococci. These were seen in great numbers, forming colonies or zooglœa. No doubt these micrococci were the poisonous principle of the water.

PARASITICAL DISEASES OF ANIMALS.

The flesh of animals affected with parasitical disease is largely consumed. The pig is occasionally the home of the *Cysticercus cellulosus*. The presence of this parasite constitutes the disease termed *measles* in the pig, but which has no analogy whatever to the malady of the same name peculiar to man. The cysticerci cellulosæ are the immature condition of the tape worm (*Tænia solium*), a human entozoon, or internal parasite. In the sheep cysticerci are very rare, but I not unfrequently meet with them in the ox.

It is stated in many works on Hygiene that 2 per cent. of Irish pigs are infected with measle worms, but I have not found this to be the case during recent years at least. In fact I rarely meet with this disease in the pigs slaughtered in Dublin.

The tænia forming parasites are destroyed by the thorough cooking of the meat in which they occur.

The "sturdy" of sheep is caused by the presence of a bladder worm (*Cœnuris cerebralis*) in the animal's brain; and the rot in the same animal and the ox results from the presence of very large entozoa (*Distomæ hepaticæ*), popularly termed "flukes," in the liver. Unless the flesh of the affected animals be sensibly deteriorated I think these diseases do not necessarily render the flesh of the affected animals unfit for food.

The *Trichina spiralis* is a small worm found chiefly in the pig, less frequently in man, the cat, rat, mouse, badger, and some other animals. It occurs in two conditions, first as a worm moving about, barely visible to the naked eye, and second enclosed in cysts. The male is about two millimetres, and the female three millimetres, in length. It is said that a single worm will produce more than 1,000 eggs. The free trichinæ penetrate from the intestinal tract through the abdominal wall into the blood and muscles. In the latter they become after a while coiled up in cysts, which ultimately become more or less calcareous. In these cysts the trichinæ retain for a very long period their vitality. When a portion of the muscle of, say a pig, containing trichinæ is swallowed by another animal, the gastric juices dissolve the cysts, and liberate the imprisoned worms. The migrations of these tiny worms from the digestive canal to the most remote parts of the body occasion severe pain, and probably the symptoms have often been mistaken for rheumatic fever. The presence in sufficient numbers of the trichinæ constitutes the disease termed *trichinosis*—a malady by no means uncommon. In Germany outbreaks of trichinosis are frequent, owing to the practice of eating pork, hams, bacon, and sausages almost or altogether raw.

The most recent of the more serious outbreaks of trichinosis is that recorded by Dr. Joesting, of Halberstadt, in the December number of the *Centralblatt für Allgemeine Gesund Neitspflege*. The flesh of a pig infested with trichinæ was eaten in a raw or smoked state by some of the inhabitants of the little town of Emersleben, on the 18th September, 1883. Three days after the slaughter of the pig, all the members of the family of the butcher who killed the animal began to suffer from diarrhœa and other symptoms of the same nature. Soon other cases followed, and up to the 11th of November, 361 cases of illness occurred in Emersleben and its neighbourhood, all the patients having consumed portions of the pig. The mortality was high, fifty-seven of the cases proving fatal. In the bodies of the deceased, trichinæ in great numbers were detected.

Trichinæ in their free state are easily destroyed by heat, but in their encysted condition they resist the action of heat for a longer time. The ova of the parasite are difficult to destroy. It is, therefore, advisable to boil pork, ham, bacon, and sausages much more thoroughly than is usually the case if we desire to secure immunity against invasions of trichinæ spiralis.

The Guinea worms (*Filaria Medinensis*) are very long and slender worms, which cause severe cutaneous abscesses. They pass from small crustaceans into water, which, when swallowed

by man, introduces the worms into the stomach. These worms are only found in certain tropical countries.*

Dr. Spencer Cobbold, an eminent authority on the entozoa, states that a common mode of the entry of parasites into the human body is in salads and other raw vegetables, eaten without having been perfectly washed. Unfiltered water often contains parasites and their ova.

Micro-organisms.

Many of the diseases affecting man and the lower animals are caused by very minute organisms, which multiply in the blood and tissues. They are termed micro-organisms, because they are not visible to the unassisted eye. Some of these objects are so minute that 50,000 of them only equal in bulk a cheese-mite.

Air, earth, and water, teem with micro-organisms. They are found on our furniture, clothing, food, and bodies. The immense majority are harmless, some are virulent. Some of these micro-organisms are the ova of minute animals, but the greater number are fungi.

A mushroom is a fungus, and, like all of its kind, subsists upon organised matter, and not, as other kinds of plants do, upon carbonic acid gas, water, ammonia, and other mineral substances. Some of the microscopic mushrooms resemble animals in having locomotive powers, and in requiring free oxygen; hence it has been contended that they are animals. These organisms are not only on the confines of the visible world, but they are also on the borderland which divides the two great organic kingdoms of nature—the animal and the vegetable. A chain, each link of which is somewhat differently fashioned, passes through each of these kingdoms; it may be that these micro-organisms are the links by which these chains are united and made continuous throughout the animated world.

The micro-organisms occurring in animals and vegetables which I propose to consider in connection with the subject of fermentation and disease, are almost universally regarded as fungi or moulds. They can generally be examined by means of a microscope capable of magnifying about 400 diameters linear. They occur in flesh, blood, organic liquids—such as broth—water, &c. They are more readily identified in muscle, &c., by treating the latter with solution of some aniline dye. The

* Dr. Thudichum's admirable monograph on the parasite diseases of animals used as food, furnished as a supplement to one of the Reports of the Medical Officer of the Privy Council should be read by all who are interested in the subject.

micro-organism acquires the colour of the dye, whilst the muscular tissue remains unstained. Ether, and acid and alkaline solutions, which dissolve or alter the form of pus and fat corpuscles and other microscopic objects likely to be mistaken for micro-organisms, have no effect upon the latter.

Classification of Micro-organisms.

Cohn arranges these micro-organisms according to their forms into the following groups:—Sphærobacteria (having globular or oval shapes), microbacteria (very minute rod-shaped cells), desmobacteria (long and comparatively large rod-like cells), and spirobacteria (spiral cells). It is clear, then, Cohn includes all these organisms under the general term—bacterium. They have, however, a very extensive nomenclature, and the term bacterium is now generally restricted to short cylindrical organisms. The simple round or oval cell is termed micrococcus, those with a ribbon-shape, bacilli and the spiral-shaped are divided into two groups—spirochus and spirillum. The micro-organisms, which are supposed to cause disease, chemical changes, &c., have names given to them which I shall mention farther on.

Micrococci.

The chemical composition of micrococci, &c., is peculiar. Unlike plants in general, they contain very little cellulose or starch. Their albuminous constituent is, according to Von Nencki, a peculiar body, which he has named mycroprotein. The thin cellulose covering of the cells is readily shewn by treatment with dilute sulphuric acid and iodine, which develops a blue hue. Most species of micrococci are very minute, but one kind, *micrococcus prodigiosus*, which sometimes colours snow red, consists of comparatively large cells. In liquid and tissue the micrococci are met with, in strings like beads, isolated, in the shape of dumb-bells, and in masses (*Zooglœa*), cemented by a gelatinous substance; they multiply by division, and it has been computed that a single micrococcus may, within twenty-four hours, produce more than sixteen millions of its kind!

The micrococci are not the most harmless of the micro-organisms. They have been found in connection with pneumonia, diphtheria, endocartitis, scarlet fever, puerperal fever, vaccinia, small-pox, and erysipelas in man, and in the cattle plague and bovine pleuro-pneumonia. The causal connection of micrococci with any one of these maladies has not been as yet conclusively proved, except perhaps in the case of erysipelas. That some species are virulent has, however, been clearly shewn by Friedlander and Frobenius and others.

According to Dr. Frank Ogston, of Aberdeen, inflammation is, except in cases of such injuries as burns, always caused by micrococci.

The powerful chemical action of micrococci has been placed beyond all doubt. The phosphorescence of fish and the production of mucus in wine have been traced to their agency. They have wonderful powers in forming pigments provided they have free access of air.

The septic micrococci are very numerous; they are found in all kinds of putrefying organic matters: I always meet with them in foul water.

The disease termed *pébrine* affecting silk worms is caused by a species of micrococcus. Pasteur has suggested a successful method of protecting the worm against the ravages of this pest.

Bacteria.

The bacteria of Cohn may be regarded as slightly more organised than the micrococci. They occur as cylindrical rods or oval cells. They seldom form chains, but are found in colonies (*Zooglœa*). Having a flagellum at one or both ends they have motile power, and their movements are very lively. They multiply by division. They are often so numerous in infusions that they form a thick pellicle or scum.

The *Bacterium termo* is found in putrefying organic matter. There is every reason to believe that bacteria are the cause of the decomposition. A large species—*Bacterium lineola*—occurs in water and in various organic infusions. The movements of these bacteria are rapid.

The bacterium termo probably plays a useful part in the economy of nature. It causes a gradual and innocuous retrograde metamorphosis of organic matter, resulting in its reduction to water, carbonic acid, ammonia, and nitrates—the inorganic food of plants.

A bacterium in milk transforms its sugar (lactin) into lactic acid. Another, *Mycoderma aceti*, is the cause, according to Pasteur and Cohn, of the acetic acid formation. Several pigments are developed by them. The disease affecting the domestic fowl, and termed fowl cholera, is declared by Semmer, Toussaint, and Pasteur to be due to the presence of a species of bacterium in the blood and tissues of those animals. Davaine and Koch have induced septicæmia, or blood poisoning, in animals by innoculating them with bacteria derived from decomposing organic matter.

The term *Microbes* is sometimes applied to the bacteria and other minute organisms alleged to cause disease.

The Bacilli.

We now come to perhaps the most formidable of the micro-organisms—the Bacilli. They are cylindrical, rounded or square at their extremities, and many have flagella which enable them to move about. Some of the rods, or strings rather, are of great length; they are termed leptothrix. Unlike the micrococci they form spores. They also multiply by transverse division.

A species of bacillus causes the rancidity of butter by producing butyric acid, but it discharges a useful part in the ripening of cheese. Upon cellulose, a substance not readily amenable to chemical solvents, it exercises a potent influence, causing it to break up and become soluble in the digestive fluids of the stomachs of the ruminants. This bacillus may, with almost absolute certainty, be found in the stomachs of these animals.

The hay bacillus (*Bacillus subtilis*) consists of rods of from 0·002 to 0·006 millimetre in length, and from 0·002 to 0·003 millimetre in thickness. They combine to form rods or filaments, some of which are of great length. They form spores about one-half the size of a bacillus, but the spores are not stained or affected by dyes. Although this organism is called the hay bacillus, it is almost invariably to be met with in all decomposing nitrogenous organic matters.

Several non-motile species (*Bacillus Septicus*) are found in putrid blood and other albuminous matters. I have seen them in sediments from water. They can exist without air. They occur occasionally in the bodies of dead animals.

The term *pathogenic bacilli* has been applied to certain species which are believed to be the cause of specific diseases in man and the lower animals, or which at least must be admitted to be in some way intimately associated with the disease.

Koch, of Berlin, has discovered a bacillus in the bodies of persons who had died from Asiatic cholera, and in pond water tainted by choleraic egesta, a comma-shaped bacillus, which he believes to be the actual cause of the disease. The bacilli were compared with other bacilli found in the intestinal tracts of persons who had died from dysentery and other diseases affecting the alimentary canal, but they were quite different from the cholera bacilli. The latter are possessed of locomotive power, and they are capable of reproducing themselves outside the human body.

All attempts to induce cholera in the lower animals by introducing the comma-shaped bacilli into their systems failed, but it has long been known that this disease is not met with in the lower animals. Two important observations were made by

Koch, namely, that the comma-bacillus, or cholera microbe, is easily killed by dessication, and that weak acid solutions, which have no appreciable effect upon other kinds of bacilli, greatly retard the development of the cholera microbe. It might therefore be advisable, should cholera invade these countries, to make vinegar or lemon-juice a constituent of every meal. Koch's theory of the causation of cholera has not as yet been universally accepted, but it cannot be shown to be untrue by other than experimental proofs.

Dr. T. R. Lewis, of Netley, has quite recently announced (*The Lancet*, September 20th, 1884) that he has discovered in the mouths and fauces of healthy persons comma-shaped bacilli which re-acted with dyes exactly like Koch's bacillus. He has not, however, shown that they behave identically under cultivation, but his observation is an important one.

The conditions affecting the life history of the cholera bacillus, favour the theory that cholera is spread by means of polluted water. We have it on the high authority of Surgeon-General De Renzy* that in India impure water is the principal vehicle in which the poison of this dreadful malady is spread. Dr. C. Macnamara, in his excellent work on cholera, refers to the presence of vibriones in immense numbers in water known to contain the *materies morbi* of cholera. In 1866 I examined the water supply on board the ship "Olive," lying in the River Liffey. I found that it teemed with micro-organisms, and that it was enormously polluted. An outbreak of cholera had taken place on board the vessel, due no doubt to the bad quality of the water used by the crew. There is, in short, an extensive literature relating to outbreaks of Asiatic cholera, ascribed to the use of infected water. Should the disease invade Dublin next year, we shall certainly be in a good condition to oppose its progress so far as a pure and abundant water supply constitutes a defensive armour. I fear, however, that this kind of armour is wanting in the great majority of Irish towns.

According to Pasteur, a micro-organism is the cause of hydrophobia. He is now engaged in the investigation of this microbe, and hopes to be able to "attenuate" its virus, so as to produce a hydrophobic vaccine, if I may use the term. Should he be successful we may hope for the extirpation of one of the most dreadful diseases to which man is liable.

Klebs and Tommasi-Crudelli, and Lanzi, and Terrigi assert that they have isolated the micro-organism of malarial fever.

According to Schütz and Löffler, Bouchard, Charvin, Wassilieff, and others, peculiar bacilli, resembling those of tubercle,

* Reports on the Sanitary Administration of the Punjâb for 1868 and 1869.

are always found in connection with glanders. Animals inoculated with them have contracted the disease.*

Several observers claim to have discovered peculiar microbes in connection with typhoid fever. In the biological department of the Health Exhibition, now going on at South Kensington, a small oval bacillus, supposed to have some relation with typhoid fever, is shown under a microscope.

Neisser and Hanser have shown that minute bacilli are always to be found in the large cells in the nodules of leprous patients. They are less than 0·001 millimetre in thickness, and have pointed extremities.

That the terrible disease popularly known as consumption, and termed by pathologists tuberculosis, is contagious, seems now to be generally admitted. The cause of the disease is the introduction into the body of a species of *bacillus*, which Koch, its principal investigator, has termed *Bacillus tuberculosis.* It is pod-shaped, and about the same size as a blood corpuscle. It is almost always solitary, seldom occurring in pairs, and never in colonies. They have no motile power. They produce spores. These bacilli are met with in large numbers in the tubercles in the lungs of persons who have died from phthisis. The results of Koch's investigations have since the publication of his inquiries in 1882† been fully confirmed, and we must now place consumption amongst the contagious diseases. I may remark here that from early times there has been a popular belief in the infectiousness of this disease.

Knowing that the presence of a peculiar bacillus in the lungs indicates true tuberculosis, we may differentiate between tuberculosis and diseases which might for a while be mistaken for it by examining microscopically the patient's sputum, or matter ejected from the lungs in coughing. A little of the sputum is placed on the object-glass and rapidly dried over the gas or spirit-flame; the film is then soaked for fifteen minutes in a solution composed of 100 parts of a saturated water solution of aniline oil, and 12 parts of a 2 per cent. water solution of gentian blue. A mixture of 1 part of nitre and 2 of water is now applied for a second or two to the preparation; after which it is washed with distilled water. Finally, it is stained by immersion for fifteen minutes in a solution, of 1 gramme of Bismarck brown in 10 cubic centimetres of spirits of wine (specific gravity ·830) and 100 cubic centimetres of distilled water. The blue stains only the bacilli, and the brown only

* See *Deutsche Med. Wachenschrift*, 52, 1882, and 11, 1883, also *Revue Medicale Française.* Dec. 1882.

† *Berliner Klinische Wachenschrift*, No. 15, 10th April, 1882.

the other substances, so that the contrast of colours makes it easy to identify the terrible micro-organism — the probable slayers of millions of mankind.

A characteristic bacillus has been found in the lungs of monkeys dead from phthisis, for these animals appear to resemble man in their diseases as well as in their anatomical structures. In the tubercles found in the lungs of the ox bacilli have also been detected. Koch has inoculated these and other kinds of animals with tubercular matter from man or the ox, and has found that the bacilli of the tubercle produced both bacilli and tubercle in the infected animal. Of course no one would try the experiment of inoculating man with the tubercle of the ox, but there is the strongest reason to believe that the terrible disease—tuberculosis in man—sometimes results from eating the flesh or drinking the milk from tuberculous cows. Dr. Charles Creighton, of Cambridge, in a remarkable work on "Bovine Tuberculosis in Man," published in 1881, stated that he believed an organism would yet be detected in tubercle—an organism which would probably have a family likeness to some other microbe organisms. Koch has detected the organism, and has shown that it is but one of the many varieties of the bacillus family. He has verified the theoretic assertion made long ago by Cohnheim, that tubercles only result from imported infection.

Klebs and Gerlach stated in 1868 that the milk of tuberculous cows was a common cause of tuberculosis in man, especially in children. Since then the question—Is tuberculosis transmissible to man through the media of meat and milk?—has been much discussed, the result being generally in the affirmative. Koch's contribution seems to me to have settled the matter, whether we hold with Schüppel that human and bovine tubercle are identical, or with Creighton that they are morphologically dissimilar, though man may become infected with tubercle from the ox.

Dairy cows are rather liable to tubercle. I always condemn the carcasses of animals affected with phthisis of a pronounced kind. The disease, popularly called the grapes, in cows, is tuberculosis. The membrane lining the great cavity of the animal is often almost completely covered with grape-like masses of tubercle. It requires very thorough cooking to destroy the bacillus of tubercle. Should there be any suspicion as to milk not being derived from a healthy animal, the safer plan is to boil it before using it.

The *Bacillis anthracis,* and closely allied species, occur in oxen affected with the so-called splenic fever, black-leg, or quarter evil, and the gloss anthrax; in sheep suffering from the carbuncular cynanche, the hæmorroidal anthrax, and the gangrenous erysipelas, and in the malignant boil of the pig. It is evident that the flesh of animals affected with such diseases should not be used as food for man.

Spiro bacteria.

I shall now briefly notice the vibriones and spirilla. One of the most interesting of the disease producing spirilla is that causing relapsing fever in man. It is called after its discoverer, *Spirillum Obermeyeri*. These organisms are minute wavy threads, which appear in great numbers in the blood during the paroxysms of the fever, and almost completely disappear when the fever subsides for the time. Relapsing fever is also termed "hunger" fever, as it often prevails during famines.

Several kinds of spirilla are found in putrefying substances, and no doubt exercise a septic action. The vibriones are also septic; they are curved rods, which exhibit rapid movements.

The coloured substances formed in paste, water, &c., are often caused by spirilla. One species is found in the tartar of teeth.

Metamorphosis of Micro-organisms.

Experiments have been made for the purpose of ascertaining—first, whether or not the artificial cultivation of harmless bacteria and micrococci might be so conducted as to render them pathogenic or disease-giving; and, second, whether or not the cultivation of pathogenic organisms might not be so managed as to moderate or destroy their virulence. As to the first of these attempts Hans Buchner asserts* that he converted the harmless hay bacillus into the deadly anthrax bacillus. According to this author it is not so much the original nature of the micro-organisms as that of the medium in which they are developed, which determines their pathogenic power. He cultivated the hay bacilius in defibrinated blood, maintained at a temperature of 36° cent., and found that after a few generations the descendents of the inoccuous bacteria acquired virulent properties. When introduced in small numbers into the blood of a healthy animal they appeared to cause its death, and the *post-mortem* appearances were similar to those of poisoning by anthrax bacilli.

Koch asserts that Buchner has not changed the nature of the hay bacillus. He points out that the material first used by Buchner for his cultivation was egg albumin which had not

* *Ueber die experimentelle Erzeyung des Milzbrandcontagiums aus den Heupilzen.*

been sterilized, and which, therefore, might have contained the bacilli which give rise to malignant œdema. These micro-organisms are not uncommon in putrefying organic substances. They develop rapidly in the blood, in which liquid the hay bacillus languishes. Koch and also Klein, therefore, are of opinion that Buchner introduced into the blood both kinds of bacilli, and that the hay bacilli soon died out, whilst the other kind multiplied under conditions so favourable to their growth.

With respect to the conversion of baneful into innocuous or comparatively innocuous micro-organisms, Pasteur claims to have accomplished that triumph, so also do Buchner, Toussaint, Koch, and others.

The blood of animals affected with splenic fever invariably contains great numbers of bacilli. As this fever is termed malignant anthrax, these organisms have been termed *Bacilli anthracis*. They resemble hay bacilli, but they do not move about. They consist of rods which divide and elongate into straight or curved filaments. They produce spores. A single bacillus measures from 0·005 to 0·02 millimetre in length, and from 0·001 to 0·0013 in thickness. Dyes affect the bacilli but not their spores. The bacilli differ slightly in form in different animals. They can exist for a long time external to the bodies of animals, and are often present in pastures. The fatal malady affecting man termed Wool-sorters' disease is caused by the spores of the anthrax bacillus,—which are occasionally attached to wool or horse-hair,—making an entry into the body.

Cultivation of Microbes.

Pasteur asserts that by cultivating anthrax bacilli in chicken broth kept at a temperature of from 42° to 43° centigrade, they gradually lose their virulence. The bacilli which appear at the expiration of twenty days' of cultivation may be safely injected into the blood of sheep or oxen. The animals generally sicken slightly, but they afterwards appear to enjoy immunity from anthracoid diseases. Pasteur now prepares a vaccine (vaccin charbonneux) as a protective against splenic fever. It is largely sought for by the stock owners of France, and it is said that the demand exceeds the supply. By a similar process he moderates the virulence of the microbe which causes fowl, or chicken cholera.

Klein has made many experiments with the view of "attenuating," as the term is, the virulence of the anthrax bacillus, but on the whole his results have not confirmed those arrived at by Pasteur. So far as relate to the protective or vaccine influence of the "attenuated" baccili, Koch, who so frequently dissents from Pasteur's conclusions, agrees with him that the continued cultivation of the anthrax bacillus lessens its pathogenic power. Koch, Gaffky, and Löffler have recently made experiments which also confirm Pasteur's statement that the anthrax bacillus can, when "attenuated," be cultivated for months or years without further change, or reversion to its original virulence. Koch and Klein agree that the spores of the bacillus are not formed within the blood.

Some interesting experiments with the Bacillus subtilis have recently been carried out by Dr. G. Vandevelde. The results appear in the current number (Tome V., Fascilule I.) of the *Archives de Biologie*, published in Ghent, Belgium. This author's researches have convinced him that the hay bacillus can exist as a ferment for a rather long period. According to Cohn, it can, when cultivated in an atmosphere free from air, evolve from certain bodies butyric acid, but Hans Buchner did not notice any fermentative action produced by it. He quotes Prazmowski's similar experience. Prazmowski introduced spores of Bacillus subtilis into glass tubes, half filled with fermentiscible liquors, boiled and sealed. In those he could find neither bacilli nor fermentation product. But this does not prove that the Bacillus subtilis cannot play the part of a ferment; for according to Brefeld and Hoppe-Seyler's researches, free oxygen is indispensable to the development and reproduction of this bacillus, and Vandevelde's culture of it in meat extracts, confirms these authors' opinion. The same authors have shown that beer-yeast does not multiply without free oxygen; and Hoppe-Seyler goes so far as to say that the same holds good for all the micro-organisms of the group of Schizomycetes, and the analytic results of Vandevelde's operations with the hay bacillus confirm that fact. Therefore, to obtain analytical results, it is evident that the bacillus must have time given to it in order to its development, and that afterwards it must play the part of a ferment to live without the presence of oxygen. It is not till after four or five days (Prazmowski seems to have expected results within four or five days), even when the culture has been carried on in sealed tubes, that products of fermentation may be expected. Prazmowski mentions that when he allowed a small quantity of air into the vassels, the bacillus was developed, but formed only a very thin crust on the surface of the liquid, which became very thick when the air was freely admitted. All this is perfectly consistent with the principle that for the phenomena of development and reproduction, free oxygen must be present, and that they take place in proportion to the quantity of air admitted.

Chamberland's experiments, carried out on the same principles, led to the same conclusions. The same objections apply to his experiments as to those of Prazmowski—that is to say, too short a time allowed for the development of the bacillus.

Vandevelde's experiments relate to the modification effected in the Bacterium subtilis in meat extracts. The bacilli were obtained by Robert's and Buchner's methods—namely, by immersing hay in water for four hours, bringing the resulting fluid to specific gravity of 1·004, and, after neutralising the excess of acid, half filling litre-flasks, closing with wadding, boiling, and cooling to a temperature of 36°, for thirty hours. When the culture was applied to meat extracts of a strength of 2·5 grammes, 5 grammes, and 10 grammes of meat to 500 cubic centimetres, the following results were obtained:—The liquid, clear at first, became turbid after twenty-four hours, but after forty or forty-eight hours regained much of its clearness, at the same time a crust, greyish white and opaque, was observable at the top, decreasing in thickness from the strongest solution to the weakest. This grey layer after thickening for some time became more shiny and presented a surface more uniform. Soon this broke up and fell to the bottom. After the disappearance of the first layer a second sometimes formed, very thin and transparent. After three weeks if a small quantity of the liquid were taken at any depth, the microscope revealed the presence of bacteria throughout the whole liquid. Mr. Vandevelde interprets these facts in the following manner The bacillus lives and multiplies during the first days at the expense of the oxygen dissolved in the liquid. When this is exhausted it rises to the surface and lives by absorbing the oxygen. But, according to Hoppe-Seyler, in liquids at rest and in fermentation the superficial layer only contains oxygen. What becomes of this layer when there is a crust one and a half millimetres thick? The superficial portion of this crust absorbs a large quantity of oxygen and prevents its access to the lower strata; there the bacillus can neither multiply nor develop itself, and to live has to produce its own heat at the expense of fermentiscible substances. Soon the crust breaks up and falls to the bottom, dies, and remains there. Another portion comes to the top and forms a new crust, and a third exists as a ferment and floats in the liquid.

Dr. Vandevelde comes to the conclusion that the Bacillus subtilis may for a certain time play the part of a ferment, and that if the experiments of Buchner are confirmed, the transformation of the bacillus subtilis is nothing more than the transformation of an organism incapable of living but for a short time in an atmosphere free from oxygen into another which can for a while produce the heat it requires for its existence by decomposing fermentiscible substances.

Disease produced by Putrid Food.

Food in a putrid state or in an incipient condition of decomposition often produces forms of *Septicæmia*, or blood poisoning of which the most common symptoms are choleraic. The toxic nature of such food seems to be due to two classes of principles. First, to the presence of micro-organisms of an infective character; second, to the spontaneous generation of crystalline principles resembling the poisonous alkaloids, such as strychnine, veratria, &c.

As to the micro-organisms, but little is known of them. I have already referred to the poisonous moulds, but it seems likely that the bacteria or bacilli in putrid food occasionally cause the illness which decomposing food sometimes produces. Nor is this poisonous food always sensibly putrid, it often has but the faintest mouldy odour; this is especially the case with preserved food, such as tinned lobster, &c.

In 1880, 72 persons who had partaken of beef and ham sandwiches at Welbeck, Nottinghamshire, suffered from choleraic symptoms, some of the affected persons died. Dr. Ballard attributed the illness to the use of the ham, and portions of it submitted to Dr. Klein were found to contain a hitherto undescribed bacillus which proved to be virulent.

Many cases of illness, apparently arising from the use of diseased or putrid meat and other kinds of unsound food, have come under my observation. In August, 1883, near Taghmon, in the county of Wexford, a sick cow was slaughtered and its flesh was consumed by forty-nine persons. It was believed that the animal only suffered from the dry "murrain," merely a kind of indigestion. Twenty-nine of the persons became very ill, and two of them died. The symptoms were similar to those observed in cases of illness from eating putrid sausages. I investigated the case, and came to the conclusion that the cause of death was septicæmia from eating food in a decomposing state. I found that all the persons who had eaten the meat fresh and hot were unaffected, but that all who had partaken of it cold and after it had been kept for some time became ill. In this case the state of disease— simple as it was—favoured the rapid decomposition of the meat. I have always noticed that the flesh of diseased animals soon becomes putrid. In the Wexford case it was surmised that the cow might have had splenic fever; but I did not detect any anthrax bacilli in its flesh, though it contained immense numbers of micrococci and bacteria. These probably acted as septic organisms merely.

Ptomaines.

The term ptomaines has been applied to crystalline principles resembling the alkaloids (strychnine, veratria, &c.) found in the dead body, in putrid flesh, and, but less frequently, in decomposing vegetable matter. They have been investigated by B. W. Richardson, Marquardt, Panum, Bergman, Schmiedeberd, Selmi (especially), Schmidt, Pouchet, Brieger, Poch, Giacomelli, and other chemists, but much remains to be known concerning them. That they occasionally cause illness and even death seems probable.* In the putrefaction of Indian corn, a ptomaine was found by Lombroso and Erba which acted like strychnine. The poisonous properties which sausages, fish, and other foods occasionally exhibit are probably due to ptomaines, not to fungi.

A poisonous alkaloid from toxic mushrooms has been isolated. It is termed *muscarine*. A very small quantity proves fatal to animals.

Dr. Dupré, of London, extracted a ptomaine from a portion of some sausage which had poisoned a number of people.

Conclusion.

The subject of the fitness of the flesh of animals affected with contagious pleuro-pneumonia, rinderpest, foot-and-mouth disease, and other maladies resulting from blood poisoning, I do not propose to consider at present.† These diseases are no doubt the results of the introduction of micro-organisms into the system, but the various *materies morbi* of these maladies have not been clearly identified. The milk of animals affected with foot-and-mouth disease has been proved to produce illness, when drunk uncooked. The milk of even healthy animals often becomes the vehicle of spreading such diseases as typhoid fever, scarlet fever, and probably diphtheria. In this city a few years ago I traced the cause of the illness—fatal in six cases—of 65 persons who had drunk milk supplied from a dairy, the owner of which had fever. The numerous outbreaks of disease which have been caused by the use of infected milk, and the strong evidence shewing the evil results of the use of the flesh of diseased

* Pouchet assigns to one of the ptomaines the following formula:— $C_{17} H_{14} N_4 O_2$.

† I have published several papers on this subject which has also been thoroughly thrashed out by Dr. Vacher, the able Medical Officer of Health for Birkenhead.

animals are sufficient reasons to warrant the systematic and skilful examination of the food prepared or exposed for sale. The reason for such examination is all the stronger when we consider that food is liable to be the abode of those organisms and alkaloids, the deadly nature of which I have briefly and imperfectly discussed in this address.

Sir Robert Rawlinson, C.B. (President of the Congress), said he was unable to speak with any thoroughness upon so technical a subject, which had been very ably dealt with by Dr. Cameron, and would therefore ask Dr. De Chaumont and Dr. Carpenter to make some observations. He could say, from his own experience as an engineer in the different towns he had inspected, that an enormous amount of diseased food was to be found throughout the country which ought, if one half of this paper were true, to be destroyed.

Dr. Alfred Carpenter (Croydon) would answer the call of the President at once, and moved a vote of thanks to Dr. Cameron for his very able and interesting address. The remarks which had been addressed to them with regard to the influence of these minute organisms were—without intending to be rude—beyond the intellectual understanding of a considerable number of those present, but he was quite certain they would gather from the address that there were very important circumstances connected with the spread of disease; that there were very important conditions to be searched out by men of Dr. Cameron's intellect and understanding; and that he, and others like him in different parts of the country, by following out these circumstances, by placing the results of their inquiries before the public, and by leading the public to understand that there was mischief being introduced among their fellow creatures by the sale of articles which were not generally fit for food, would promote the health of the people and the ultimate advantage of all concerned. The way in which impure articles of food were sold among the poor and distributed by the producer, the way in which the meat of diseased animals was foisted upon the market and sold as good or second-class meat, tended very much to the production of disease; and the remarks of Dr. Cameron ought to induce them strongly to combat the development of trade in impure articles of food, and by this means assist in promoting the health of the people. Although all of those present might not be able to follow the details of the paper, the inferences drawn from them would not be lost sight of, and he hoped those present would accord the author their thanks.

Surgeon-General de Renzy (Bray), who seconded the motion, gave from his Indian experience instances of the prevalence among certain natives of round worm, the ova of which appeared to have been

derived from impure drinking water, the disease ceasing upon the natives being supplied with pure water. In another remarkable case, round worms prevailed to an immense extent among the lunatics in an asylum near Calcutta; the cause of the prevalence of the parasite was investigated again and again, apparently with little result, until suspicion fell on the water supply; and in the end, when the old tanks were abolished and only the pure water brought in was used, the worm was got rid off from the asylum. The evidence with regard to Guinea worm was also to the same effect. This worm formerly prevailed considerably in Bombay, which was then supplied with water from foul and stagnant tanks, but since the introduction of a good water supply in 1865, the parasite had become extremely rare.

The motion for the vote of thanks was then agreed to, and Dr. Cameron briefly replied in acknowledgment thereof.

On "A New Process for Treating and Drying Blood, so as to fit it for use as Manure without creating a Nuisance," by W. G. Strype, C.E.

The rapid manner in which the blood of animals decomposes, emitting offensive emanations dangerous to health, has presented considerable difficulty in preparing it for use. Blood contains about 75 to 80 per cent. of moisture, which has to be evaporated in order to prepare it in convenient form for agricultural or other purposes, but the operation of drying, as usually performed, tends to aggravate the nuisance by the increased emission of noxious vapours. In some measure this difficulty has been lessened by drying the blood in closed vessels heated externally with steam, or by other means; the vapours being conveyed from the vessels under a large furnace, and their noxious character more or less destroyed by the fire, and mixing afterwards with the products of combustion, pass up the chimney shaft; the emanations considerably diluted enter at a high level into the atmosphere, and consequently their evil effects are not so marked. In hot climates, such as are met with in the South American States, where the slaughtering of cattle is carried out upon a very extensive scale, the blood is frequently allowed to run waste, the slaughter-houses being situated alongside a river. Sometimes the blood is collected and dried by means of the sun, but this process is attended with the most offensive and injurious emanations, such as would not be tolerated in the vicinity of any populous locality. The high value for agricultural purposes which dried blood possesses has led to its being prepared for use in such localities by this rough method of exposure to the sun's heat, notwithstanding the nuisance it has caused. In our large towns, where considerable numbers of cattle are daily slaughtered for the purpose of food, most of the blood is run to waste, owing to the difficulty of treating it; but when it is treated the process is usually attended with dangerous emission of noxious matters; so that I trust this Congress of the Sanitary Institute of Great Britain will regard the subject as one of interest from a sanitary point of view, and anything calculated to remove the cause of the nuisance of importance.

My attention has been directed to this subject in connection with the manufacture of sulphate of alumina, and some of the many sanitary purposes to which that material can be advantageously applied. It has been generally known that the ordinary hydrated sulphate of alumina has the property of abating the nuisance arising from the naturally rapid decomposition of blood, but the quantity necessary to do so is considerable, as it is almost impossible to thoroughly mix the dry sulphate with the blood so as to secure deodorization. During the great number of experiments which I made I found the same difficulty, which is due to the fact that the dry sulphate, as usually added, dissolves very imperfectly in blood, and consequently leaves large portions unacted on, so that practically no beneficial effect follows. The treatment with sulphate of alumina has not therefore been a success, or indeed employed on a large scale. Hydrated sulphate of alumina, as now manufactured, is very soluble in water and especially in hot water, and I found that if the sulphate were previously dissolved in water all the difficulty would be overcome, as the solution so obtained could be added to the blood so as to be intimately incorporated with every particle of it. I found that so small a proportion of the hydrated sulphate of alumina as the one-fiftieth, or even the one-sixtieth part, when added in the form of a solution, was quite sufficient to entirely destroy the offensive and dangerous odour, and the resulting mixture of blood and sulphate of alumina could be afterwards dried to prepare it for use in an open pan heated with a fire or other means without nuisance; the slight odour emitted during the process of drying is rather a pleasant one than otherwise, somewhat resembling that from the roasting of a fresh joint of beef. The most desirable method of adding the sulphate to the blood is to place in a shallow tin dish of suitable dimensions a small measured quantity of the solution, containing about three-quarters of a

pound of the sulphate of alumina, and to allow the blood from the slaughtered animal to flow into it. A full-sized animal gives about forty-five pounds weight, or about four-and-a-half gallons of blood. A collecting vessel is placed close at hand, and the contents of the dishes are from time to time poured into it, where it shortly afterwards more completely coagulates, and not the least trace of offensive odour occurs. This method of treatment, which I have patented in this and in other countries, is now being carried on upon a working scale by the Dublin and Wicklow Manure Company, who collect all the blood from the animals slaughtered at the public abbatoir which the Corporation have recently erected in this city. The blood is conveyed to the company's works at Ballybough Bridge, and there dried in open pans, without the emission of any offensive odour, or the least inconvenience to the workmen, and without any danger whatever to public health. All the vessels used in the several operations are rinsed out with the solution of the sulphate of alumina, and are kept by that means inodorous and clean. The dried blood obtained is of high fertilizing value, and contains nitrogenous matter equal to 14 or 15 per cent. of ammonia.

I have also had this treatment carried out upon a large scale, and with considerable success, at some of the slaughtering establishments (or *Saladeros*, as they are locally called) at Monte Video, in the State of Uraguay, where upwards of 500 animals are slaughtered in each Saladero per day on the average during the season; and very extensive operations are now being made for working the process in this and other countries, where the slaughtering of animals is carried on extensively. These animals are smaller than ours and do not yield more than about 35 lbs. of blood each. The blood drains across the slaughtering floor and passes into a small conduit placed along one side of it, which leads it into one of two or more collecting tanks into which the solution of sulphate of alumina is placed. In a short time the mixture thickens, and the contents of the collecting tanks are shovelled out and spread upon the surface of the ground, where they are exposed to the heat of the sun. The climate being a hot and dry one during the slaughtering season, the blood is perfectly dried fit for exportation in a day or so, and no emission of offensive or dangerous odour takes place; while an important material can in this way be turned to a useful purpose, the greater portion of which was hitherto lost, being a source, even when wasted, not only of considerable nuisance, but also the loss of a valuable fertilizer, which is now by this process turned to profitable account by those engaged in the industry.

It will be seen that the process of drying and preparing blood for use by this method is of extreme simplicity, not requiring any extensive arrangements or expensive plant. The quantity of sulphate of alumina required is so small as not to appreciably effect the cost of production, while the dried blood obtained is readily prepared and is of considerable value, being at the present time worth about £6 or £7 per ton.

Mr. Moss, F.C.S., Hon. Sec. of the Section (Dublin), said the great simplicity of the process commended it to manufacturers. The employment of the aluminium sulphate in solution instead of in the solid form, ensured that intimate mixture that was necessary in order to obtain the full effect of the reagent. If the process could be successfully applied it would facilitate the utilization of an immense quantity of valuable material.

Dr. H. C. Bartlett (London) had also been struck with the simplicity of the process, which was one of the first essentials in dealing with a matter of the kind. The main questions for consideration were whether it could be applied inexpensively for the removal of a nuisance, whether it payed or not, and whether it could be made to pay. If it would not pay he was afraid that, however valuable it might be in getting rid of the nuisance, it would not be adopted, except as a necessity. In many small country towns abbatoirs were badly looked after, not because the inspectors were remiss, but because they could not always attend at the time of slaughter; but if this system could be adopted he had no doubt nuisance would be removed or avoided; in such instances this process would be invaluable. He had inspected the manure works where this new process was being carried on, and there was none of the disgusting odours of blood and decomposition which usually rendered such an operation one of the most noisome with which he was acquainted. Taken altogether, this easy and effectual disposal of the refuse blood, which cannot by this means become a nuisance, is very satisfactory.

Prof. W. H. Corfield, M.A., M.D. (London), said it was provided by an Act of 1844, that in thirty years from that time, certain trades or businesses which were declared to be offensive trades should cease to be carried on in or near London, among them being the boiling of blood and the slaughter of cattle. Any medical officer who had had to do with it knew what an offensive business blood-boiling was, and what a difficult thing it was to prevent nuisance in the neighbourhood; and as to slaughtering too, how difficult it was to superintend a number of slaughter-houses scattered about, and to prevent the sale of the meat of animals that had not been killed but had died. In 1872 a tremendous outcry was raised by the London butchers because they found out that in two years they would not be able to continue slaughtering in private slaughter-houses, and the result of their outcry was that a Bill was passed enabling the business of slaughtering to be carried on under certain regulations. That showed how difficult it was to get rid of these trade nuisances. The special regulations provided, that if the owner of a business did not get all the necessary appliances and keep them in good working order, action could be taken against him to make him remove to some place outside the parish; but this Act was, if not quite, almost a dead letter; it was exceedingly difficult to carry out, as the people proceeded against brought evidence to show they had done all that was required, and it was by no means easy to bring a case to a successful issue. The result of it all was that a nuisance, admitted to be so as long since as 1844, continued to exist. As to the process of Mr. Strype he would, as one of the judges who had not yet made their report, express no opinion, except to say that in what he had witnessed there was none of the nuisance experienced in an ordinary blood-boiling establishment, that to be thoroughly successful it must be carried out on a large scale, and that therefore it would probably be a help to the construction of public abbatoirs, and the abolition of private slaughter houses.

Prof. F. de Chaumont, M.D., F.R.S. (Southampton), who had also had an opportunity of visiting the works, considered it his duty, as one of the judges, to be equally reticent, but could corroborate what had been said as to the simplicity of the process and the absence of nuisance.

Dr. F. Vacher (Birkenhead) thought that inasmuch as the success of the plan depended upon its being carried out upon a large scale, it would have a tendency to encourage the adoption of large public slaughter-houses, in place of small private ones, and it would thus be productive of good. In many small towns every little butcher's shop had its slaughter-house, and blood did not pay anyone to collect, and so was a distinct loss to the butcher and a nuisance to the locality. It might therefore be found worth while to supply butchers doing a small business, with the solution of sulphate of alumina with which they could treat the blood; this could then be collected once a week or once a fortnight, and it would then only have to be dessicated.

Dr. Charles A. Cameron (President of the Section) said Dublin had a very good *abbatoir* which was not worked at present to anything like the extent that had been hoped for when it was established four or five years ago. It was just outside the city boundary, and they could not compel the butchers to use it. He hoped an Act of Parliament dealing with the question would be passed, due regard being paid to vested interests, and that slaughter-houses in the city would be done away with.

Mr. STRYPE (Dublin), in reply, said the observations on his paper had been very friendly. There was no difficulty in carrying on the process on a large scale, when he believed it would pay very well indeed. The price paid to the corporation was equal to £1 per ton of wet blood, containing about seventy-five per cent. of water, so that it required four tons of wet blood to produce one ton of dry blood, and therefore the cost of the raw material amounted to £4 per ton. The cost of preparation, when carried out upon a tolerably large scale, was from £1 to £1 10s. per ton, including sulphate of alumina, royalty and all charges. The scale upon which they were now carrying out the process was not so large, from the circumstances mentioned by Dr. Cameron, but the process, even as now carried on in Dublin to the extent they were limited to, had already shown a moderate profit.

On "*The Influence of Food on Health*," *by* FRANCIS VACHER, F.R.C.S.Edin., F.C.S., Medical Officer of Health, Birkenhead.

In any comprehensive review of public health the influence of food supplies cannot be left out of the reckoning. The influence is apparent year by year. One year, it may be, an abundant harvest makes corn cheap, legislation restrictions make butchers' meat dear, and a run of rough weather along the coast practically forbids the use of fresh fish to all but the wealthy. Another year matters are reversed, wheat is up to 50s. a quarter, meat is within reach of the poor, and the fisheries are exceptionally successful. The influence is not less apparent in different countries. One nation's food supply consists mainly of oats or rye and milk, another's chief supply is potatoes, salt meat and fish, and butter milk; another's is sour bread and wine, and fresh fruit. The influence is apparent in comparing the health of town and country, or summer and winter. The influence of food on the health of small communities, families and individuals is often not less striking.

In truth, in trying to solve any health problem, food becomes a very important factor. Is the general death rate or zymotic death rate the subject of investigation, or an increased infant mortality, or the cause of a specific epidemic or endemic disease; in every case food, no less than air, water, climate, ground, occupation, environment, and many other things, must be carefully considered.

Of course, if the food supply is sufficient in quantity, sufficiently varied, excellent in quality, of a kind suited to the season and climate, and adapted to the occupation and habits of the consumer, if it be eaten slowly and allowing regular intervals of time sufficient for digestion and rest, its influence can be only beneficial. The question, therefore, which immediately concerns us, and which it is proposed now to discuss, is—

Under what circumstances is food other than beneficial?
Under two circumstances.

(1). The food, faultless in itself, may be so unwisely used that it, or a portion of it, may be other than beneficial. Thus—

a. It may be in excess.
b. It may be insufficiently varied.
c. It may be ill adapted to season or climate, occupation, habits, or temperament.
d. It may be eaten too quickly, or at too high or low a temperature.
e. It may be eaten just before or after extraordinary physical exertion, just before sleep or sea-bathing, &c.

(2). The food may itself be defective. Thus—

a. It may be too hard or tough.
b. It may have undergone acid fermentation.
c. It may have undergone putrefactive change.
d. It may be injuriously adulterated.
e. It may be diseased.
f. It may be infected with the contagium of a human disease.

The circumstances, as set forth in my first list, under which wholesome food may influence the consumer's health prejudicially, are circumstances each individual for the most part controls for himself. They are thus matters of personal hygiene—problems every one must solve for himself from his experience and observation, and if necessary, assisted by the advice of the family physician. No hard-and-fast line can be drawn with reference to them, no rule laid down. Having mentioned them, therefore, I pass on to consider the various conditions which depreciate the quality of human food, or render it positively injurious.

Hardness or toughness is a defect more frequently manifest in butchers' meat than in other food; but cheese, salt fish, fresh fruit, rye or oaten bread, may be hard enough to be injurious to the consumer, a considerable proportion passing through the alimentary tract undigested, and acting as a mechanical irritant. In butchers' meat toughness is due to several causes; chiefly, I believe, to the meat being badly cooked, or too fresh, or being derived from aged animals, especially entire males. Some samples of jerked beef and ships' pork occasionally met with are so dry, that after ample soaking and cooking, they become little more nutritious than leather. Fortunately this property of food is one readily appreciable by the senses, and one any housewife is competent to judge of.

Sourness.—This term is, I think, not generally understood by the public. Most people know that when milk turns sour the sugar in the milk has become converted into an acid, but they have not heard of the little active egg-shaped bacterium, by whose action this change is brought about. It is probable that whenever souring takes places the process is started by means of a low form of organism growing and multiplying, in much the same way as alcoholic fermentation is brought about by another organism. Souring does not necessarily render milk unfit for food, as the change effected is not dissimilar to that which takes place when digestion commences in the stomach, but milk thus changing or changed readily putrefies and forms a soil for the growth of germs undoubtedly injurious. For instance, the rod-shaped bacillus of so-called "blue milk" only grows in an acid medium, and probably the oidium, &c., can only infect acid milk. Butter which is not actually rancid is often a little sour from the bad practice of making it from sour cream; that is, the curd (which usually exists to the amount of about 4 per cent.) is not free from acid when the butter is made. In this way often rancidity begins.

Bread is also often sour, though less frequently in this country than in France or Germany. Sometimes the bread is made sour intentionally; especially is this the case in bread made with leaven; but in this country, when either bakers' bread or home-made bread is sour it is due to fermentation having been allowed to proceed too far. The acids present in such bread are acetic and lactic. Cheese also is sometimes sour, especially inferior qualities and sheeps' milk cheese. Finally, butchers' meat is occasionally sour. Sometimes, I believe this is due to the animal having been affected with rheumatism, but more frequently to the presence of milk in the meat. I have seen many such cases. The animal is killed shortly after calving. There is what is called "milk fever," or the udder is too inflamed and

sore for milking. The sourness of butchers' meat is also, doubtless, due to other causes. Of course, sourness in meat to be injurious must be well marked, as healthy meat has naturally a faint acid reaction. Generally, it may be said that sourness in foods renders them liable to the attacks of mould and fungus and to decomposing agents.

Putrefaction.—Just as the little *torula*, the yeast granule, excites fermentation in liquids containing sugar, in which it grows, so do allied organisms excite putrefaction in animal or vegetable matter. Thus putrefaction is a form of fermentation, or rather many forms of it, excited by bacteria of different kinds. The foods which are most frequently exposed for sale when undergoing putrefaction are cheese, game, fish, sausages, cooked meat, and fruit. It is a curious fact that game, even in an advanced state of putrefaction, may be eaten with impunity; but it occasionally gives rise to considerable intestinal irritation. Cheese, too, not merely attacked by mites and blue mould, but swarming with the bacteria of putrefaction in parts, and bitter to the taste, is doubtless often eaten without ill effects. However, cheese in this condition is not wholesome, and cannot be eaten without risk. Fish, undergoing putrefaction, is probably still more dangerous as a food, and in this country rarely used, even by the very poor; yet it is known that the Chinese, Burmese, and some other nations habitually eat putrid fish as a condiment, and without any known ill effects. Sausages, brawn, cooked meat from pies and tins, &c., have often been known to produce symptoms resembling those of acute poisoning in families or groups of people partaking of them. On examination of the viands it is seldom that any definite poison has been discovered—there has been some softening, a slight putrid smell on boiling, and the ubiquitous bacteria. Uncooked meat is not rarely offered for sale in a putrefying state, especially the cheaper portions of a carcase, the brisket, strippings of ox heads, &c. Such meat finds a market in poor neighbourhoods late on Saturday nights. Some of the nausea and vomiting ascribed to drink may be due to suppers of such meat. Fruit also, of various kinds, is retailed in the streets in a half-putrid state, especially in July and August, and is one of many causes of summer diarrhœa. As the signs of putrefaction are manifest in fish, flesh, fowl, or fruit, if people eat tainted food they do it knowingly, or for want of the exercise of ordinary care.

Injurious Adulteration.—It will hardly be necessary for me to point out that a large proportion of the adulteration that takes place is not, strictly speaking, injurious. Thus, when the flour of rice, barley, or maize is added to wheat flour, or a preparation of sweet beef fat is added to butter, the purchaser may be swindled, but he buys a good wholesome food nevertheless. Of the ordinary foods in use in this country, I think I am justified in saying that only a few are injuriously adulterated. Flour is said to be adulterated with gypsum (sulphate of lime), chalk (carbonate of lime), and ground soapstone (silicate of magnesia); but since the passing of the Adulteration Acts it must be to a very limited extent, as any of them could be detected by simply burning the flour. Much has also been written on the adulteration of bread with alum, but I doubt if this is practised to any extent. It is a significant fact that pure wheat flour has been found to contain a quantity of alumina equivalent to from 2 to upwards of 40 grains of ammonia alum for 4 lbs. Thus, it is not improbable that the alumina occasionally detected in bread is a sophistication effected by Nature. The presence of lime or soapstone in food might produce constipation and dyspepsia, and alum might do this or might simply retard digestion. Milk is dishonestly manipulated mainly in two ways, by watering and skimming. When the added water is pure and the cream is removed with a clean instrument, and clean hands, the milk, though less nutritious, is certainly not injurious. The foreign substances added are for the purpose of keeping it or increasing its density; they are soda, borax, salicylic acid, salt, sugar or glycerine. Some of these, especially salicylic acid, might prove injurious to children and invalids. Confectionery is often coloured with mineral substances, as white and red lead, chromate of lead, vermilion, verditer, the bright green arsenite of copper, picric acid, and the aniline dyes, with many others, all of which are positively injurious. The so-called essences added as "flavourings," acetate of ethyl, acetate of amyl, &c., are scarcely less unwholesome. Tinned peas and green vegetables, fruit, and pickles, are well known to be adulterated with salts of copper, probably acetate of copper. Happily, mineral substances are all readily detected by analysis. But if there were no demand for bright tints in confectionery, pickles, &c., there would be no temptation to manufacturers to add such adulterants. The symptoms which may arise from eating such food are those of acute poisoning. Sweets are also largely adulterated with gypsum, which I have already stated is constipating, and occasionally coloured with gamboge, a powerful drastic. Mustard and egg powders are said to be sometimes coloured with chromate of lead, and curry and cayenne pepper to be coloured with red lead, &c., but I should think such adulteration uncommon in this country.

Diseased Food.—The foods which may be themselves diseased are corn, milk, butchers' meat, fowl, fish and fruit.

The most common diseases of corn in this country are bunt, smut, and ergot. Bunt frequently affects wheat, and grows within its seed, producing a fine powder. This powder feels greasy when rubbed between the fingers, and has an unpleasant smell. Smut commonly attacks barley, oats, and rye, seldom wheat. It produces a powder finer than bunt, and has no smell. Ergot, for the most part confined to rye, but also attacking other corn occasionally, develops early in the grain, taking the place of the solid contents. It has a sour smell. The spores of all these parasites may be seen under the microscope, those of smut as small round granules, those of bunt round and reticulated and three or four times the diameter of smut, and those of ergot egg-shaped. Bunt and smut certainly render the flour or bread containing them less wholesome; the latter is said to produce diarrhœa. Ergot is even more deleterious, exciting a specific action on the involuntary muscles, and if the use of food containing it be long continued resulting in the disease known as ergotism.

Most fruit is liable to the attacks of various fungi and of other parasites, which may give rise to a considerable amount of gastric irritation and depression, or even to choleraic symptoms. Indeed it is probable that acute attacks of diarrhœa ascribed to the ingestion of unripe fruit are often due to the presence of parasites. As parasitic disease tends to affect the surface and the centre of fruit, a safe precaution is to remove the peel and the part lying next the core or the stone. It is also well to remember that all risk is avoided if the fruit be thoroughly cooked.

Milk may be diseased in three ways; it may be derived from a cow suffering from a specific epizootic disease, from a tuberculous cow, or from an inflamed udder. The danger of milk being specifically infected is not nearly so great as might be inferred, the milk secretion being, in most epizootic diseases, entirely arrested. The only two diseases in which it is usual for the milk to continue to be secreted are pleuro-pneumonia and foot-and-mouth disease. Milk from pleuro-pneumonic cows has been commonly sold, looks wholesome, and is not known to produce any ill effects. Milk from a cow affected with foot-and-mouth disease is diminished in quantity, richer in butter, sometimes contains vibriones, &c., and readily sours. It is certainly unwholesome, and, there is no doubt, when ingested raw, may produce in the human subject a disease closely resembling, if not identical with, foot-and-mouth disease. The question whether milk derived from tuberculous cows can be used for human food with impunity has recently been much debated. It is exceedingly difficult to get direct evidence bearing upon the point. Having read much upon the subject, I am yet unable to say a good case has been made out against such milk. Still I think it is only reasonable to admit the possibility of tuberculous milk infecting the consumer. The disease is not uncommon among cows. They may be in good condition and good milkers and yet have tubercle. Cows, especially those in high condition, readily get inflamed udders, the common causes being cold, overdistention of the udder from being long unmilked, bruising from unskilful milking, leaving a residuum in the udder, and pressure from an awkward way of lying. Milk from such udders is usually said to be gargety. The milk is ropy or quite curdled, and may contain pus, bloody serum and other effete matters, and could not meet with a ready sale by itself. Mixed with the rest of the produce of a dairy it may escape notice. How then may milk infected in either of these three ways be rendered innocuous? Of course if the milk is streaky, or the least bloodstained or smells bad it should be rejected. But as milk may be diseased and yet afford no physical sign of disease, it is well that it can be rendered wholesome by the simple process of boiling.

Of diseased fowl and fish but little is known. Poultry suffer from many diseases, but the only one there is reason to believe may prejudice the flesh so as to make it unfit for food of man is fowl cholera. Though called fowl cholera, ducks, turkeys, geese and pigeons are all subject to the disease. The flesh is somewhat redder than natural, the liver softer, the heart speckled with red or dark spots, the intestines are inflamed and marked with red or livid patches. However, in birds carefully prepared for the market there may be little evidence of the disease. Fish apparently healthy and in season have occasionally affected consumers very seriously, the symptoms resembling those of poisoning; but attempts to isolate any poison have failed, and it is thought their flesh may have been tainted by their having fed on diseased or unwholesome food. It is known also that fish are subject not only to entozoa, which do not commonly render them unfit for food, but to many parasitic diseases, which make them unfit for food, the visible signs being a fungus which eats its way from the surface into the sound flesh.

As regards the diseases of animals from which butchers' meat is derived there is more exact information, but I have only space to refer to the matter very briefly here. The diseases ordinarily met with or likely to occur in home-bred or imported animals which should be regarded as rendering the meat unfit for food of man are: *in oxen and sheep*, cattle plague, epizootic pleuro-pneumonia, anthrax, and sheep-pox; *in swine*, typhoid fever, epizootic pleuro-pneumonia, quinsy, and the parasitic diseases known by the presence of cysticerci and trichinæ. Most of these diseases disfigure the carcass sufficiently to exclude it from the meat market. However, pleuro-pneumonic beef is often exposed for sale, and may generally be known by its darkened appearance and the absence of firmness. Cysticerci if swallowed alive produce tapeworm in the human subject, and trichinæ under similar conditions produce themselves in great numbers, giving rise to a terrible disease, which may prove fatal. Cysticerci give to pork a measled appearance sufficient to attract attention, but the fine speckling indicating the presence of trichinæ is not likely to attract attention ordinarily. The effect of eating meat tainted with anthrax, especially if the meat were underdone and the person eating it had a mouth-wound, might be to produce anthrax itself. The symptoms the other diseased meats would be liable to produce would be depression, surface coldness, diarrhœa, and vomiting.

Besides the diseases I have named, there are others which depreciate the quality of the meat and render portions of the carcass unfit for food of man, or in their later stages render the whole carcass unfit for food of man. These are tuberculosis, foot-and-mouth disease, hoof-rot, rheumatism, dropsy, and liver-fluke. What steps, then, should the public take to guard against the ill-effects of diseased meat? Till more efficient inspection is obtained, which by the way is greatly needed, all that can be done is to be very careful to reject meat which is not firm, and does not look and smell perfectly good, and to make certain that every joint is thoroughly cooked.

Infected Food.—Almost every kind of food is liable to be infected with the germs of human disease. These germs are very abundant. They are given off from the lungs in one disease, from the throat in another, from the skin in another. We know that they rest on the surface of rooms, and furniture, and clothes, and foods; and it certainly appears that those resting on foods are *prima facie* more likely to retain their vitality than others. Some of them are killed by drying, and probably all may be killed by the action on them of the oxygen in the air. In contact with most foods they obtain moisture, are sheltered from the action of the air, and furnished with such food as they can assimilate.

As, however, they cannot penetrate below the surface of foods there is practically no risk of infection from such things as meat, poultry, fish, vegetables, &c. Bread, biscuits, butter, cheese, fruit, and some groceries which are not subjected to any cooking process after they leave the vendor's shop may all become the carriers of infection. There is one food, however, which beyond all others is specially susceptible of infection, that is milk. The risk there is of infection being conveyed by means of all other foods is small indeed in comparison to the risk in the case of milk. Again and again have specific outbreaks of disease been traced to contagium mixed with the milk. Last year Mr. Ernest Hart read a paper at the Social Science Congress, in which he gave particulars of 82 epidemics due to infected milk which had occurred since 1873. The total was made up of 53 of typhoid fever, 17 of scarlatina, and 12 of diphtheria. The number of cases of disease traced to the drinking of infected milk is, according to Mr. Hart, in round numbers, as follows:

Typhoid fever	3,500	with	400	deaths
Scarlatina	800	"	120	"
Diphtheria	700	"	60	"

How many other human diseases, besides these three familiar ones may be carried by milk is uncertain, but it is exceedingly probable that measles may be thus conveyed, and almost certain that one way in which diarrhœa spreads is by means of the cheap watered milk supplied to the poor. I have elsewhere pointed out that milk is also liable to be contaminated with the contagium of glanders and some other animal diseases. It is hardly necessary to state that in most of the instances in which typhoid fever and diphtheria have been delivered in the milk-can, the contagium has been introduced by means of water—the dairy vessels have been rinsed out at a polluted spring, or the milk has been deliberately diluted. The remedy in the case of infected milk is, as in the case of diseased milk, to take care that it is thoroughly boiled.

The subject of the influence of food on health is so far-reaching and the time at my disposal so limited, that my remarks, as I cannot but be conscious, have been somewhat superficial. Still, I trust that my experience as a meat inspector and food analyst has at least enabled me to keep within the limits of truth and common sense.

Surgeon-General A. C. C. De Renzy (Bray) called attention to the fact that the dangers involved in the use of infected milk had only recently become known and appreciated. Previous to the year 1868 he believed there was no suspicion that typhoid fever or any of the zymotic diseases were spread by means of infected milk, and certainly it was very remarkable that up to that time the danger of such a medium had been unsuspected.

Professor Hull (Dublin) called to their remembrance the outbreak of typhoid fever in Dublin, which, he believed, Dr. Cameron had been the means of tracing to the milk supply. Ever since he himself had taken the greatest pains to secure that the milk consumed in his household came from a pure source; while as to the milk he used for making his mid-day coffee, and which came from a source with which he was not acquainted, he invariably boiled it before using it, and so knew that he was comparatively safe.

Dr. J. W. Moore (Dublin) said the outbreak referred to was fully investigated at a largely attended meeting of the Medical Society of the King and Queen's College of Physicians, and the almost universal opinion expressed by the speakers in the debate was that Dr. Cameron had conclusively proved the connection between the epidemic and the use of polluted milk. There were so many other cases, in which a similar connection had been traced, that it was now admitted on all sides that impure milk was capable of conveying disease. The maladies most likely to be carried in this way were undoubtedly typhoid fever and scarlatina.

Dr. W. J. Simpson (Aberdeen) said there was, unfortunately, an idea in Scotland that the addition of water to milk was not adulteration; and this might, perhaps, be so if the water added were pure, but unfortunately they had had experiences of water from contaminated wells being put into milk, by which means disease had been spread in the large towns. In regard to food, they required better inspection, and more stringent penalties for offenders.

Mr. G. J. Symons, F.R.S. (London), would not have risen to speak upon a medical question, but desired to mention that the neighbourhood in which he lived, in the North of London, suffered last year from a violent outbreak of typhoid fever; it was said to have been traced to a farm near St. Alban's, where water taken from a contaminated well had been used in washing the vessels used for the milk supply. The question of fines had been alluded to; now in the case just mentioned the man who served the milk supplied over 2,000 customers, and an outbreak of such a kind being said to have come from his establishment would be a heavier punishment to him than any pecuniary penalty. But the milkman was supplied from a large number of farms, and as soon as that particular farm was proved to be a source of disease his supply from it was stopped. The matter did not, however, end here. One would have thought that the farm would have been put thoroughly right, but that did not seem to have been the case, for it was said that milk from it was supplied to St.

Alban's, and an outbreak of typhoid fever had since occurred in that city.

Dr. S. T. Taylor (Norwich) said he had frequent requests for pills to cure ailments due to the extreme purity of the bread we use. Bread was getting purer every day, and an admixture of bran or the use of whole meal would be of very great advantage.

Dr. Edgar Flinn (Kingstown) gave an instance from his experience in Staffordshire of the dissemination of scarlet fever by milk.

Dr. Charles A. Cameron (President of the Section) agreed that there was now very little injurious adulteration in the foods in use in the United Kingdom. Dublin was the only city in which the first Adulteration Act was brought into operation. He found many articles were adulterated, though not to a considerable extent: bread, to a small degree, with alum and with potatoes; tea was sold consisting largely of leaves containing little or no soluble matter; confectionery was adulterated with plaster of Paris—they had obtained eight convictions in one day; sugar stick with vermilion (sulphide of mercury) for the red, and chromate of lead for the yellow; *terra-alba* was largely used in the cheap kinds of confectionery. Now no article was adulterated to any extent worth speaking of except milk. In regard to the Dublin fever outbreak, the dairy in question was not supplied with any sanitary accommodation whatever; there were three cases of fever in the house, and the house refuse was carried between two rows of cows and thrown upon the manure heap in the dairy yard. The milk absorbed the emanations from the manure heap.

Dr. F. Vacher (Birkenhead), replying to Dr. Taylor's observations, said he was a very warm friend of the Bread Reform Movement, which had now taken so strong a hold in many towns. He believed its promoters placed in our hands a bread that was not irritating, and which yet contained all the nutritive constituents of the grain. To meet the difficulty experienced in tracing out the source of an outbreak of fever, where the milk supply was suspected, he had obtained the insertion of a clause in the Birkenhead Improvement Act, 1884, by which every milk vendor within the borough was required, on application from the sanitary authority, to give a list of his customers supplied with milk on any day or days, and their addresses, for which the local authority were permitted to pay a small charge.

On "Potable Water and its quality, as supplied to the Towns of Ireland," by Charles A. Cameron, F.R.C.S.I., S.S.C.Camb., M.K.Q.C.P.

The results of many years' experience in the examination of potable waters have convinced me that a very large proportion of those used in this country are below the standard of a fairly pure water. No doubt a similar state of things exists in other countries. The extent to which the health of communities is affected by the quality of their water supplies has not been accurately determined; but there is evidence to prove that, in the case of many districts, the state of public health has been improved by the substitution of pure for impure supplies of water.

There is some difference of opinion as to what constitutes the purest potable water. The majority of chemists appear to consider such water as that which Glasgow obtains from Loch Katrine the best for all domestic purposes. This water really differs but slightly from rain. One gallon (70,000 grains, or ten pounds in weight), of it evaporated to dryness, leaves only from 2 to 2½ grains weight of solid matter. If the latter be burned, about one half (the organic part) disappears, leaving the mineral, or inorganic part. Loch Katrine water, therefore, contains only about one part of organic matter and one part of mineral matter in 70,000 parts. This kind of water is usually not very sparkling. Many persons do not like its "flat" flavour so much as that of water taken from springs or wells, and containing from 10 to 100 grains of solid matters per imperial gallon. There is generally less dissolved gas in the soft water of Loch Katrine, and its temperature is in summer higher as compared with spring and well waters.

Some persons believe that very soft waters are not so wholesome as moderately hard ones, owing to the absence of lime compounds in the former. No doubt this earth is an abundant constituent of animals; but there is no good physiological proof of the truth of the assertion that the lime of our bones is procured from the water we drink. By far the greater portion of the lime in the animal system is combined with phosphoric acid, whilst in water it is united with carbonic acid and sulphuric acid (in some waters there is chloride of calcium). It seems strange, therefore, that lime should be obtained from water and phosphoric acid from some other source. I am one of those who prefer soft water to hard water for a town supply; for although in many instances the flavour of hard water is pleasanter, yet for cooking and washing purposes the soft water possesses great advantages over the hard one. Beside, I do not believe that the lime in water contributes to the nutrition of animals.

The Dublin pipe-water is derived from the impounded drainage of a mountainous region. It contains 4½ grains of solid matters—one-half of which consists of organic matter, nearly altogether derived from peat.

The water supplied to Irish towns contains, with very few exceptions, a larger amount of solid matters than is found in the Vartry water. The colour of the latter and of Loch Katrine water is a very faint yellow, whilst most of the high-pressure waters supplied to the Irish towns have a colour varying from a faint yellow to a brownish hue.

In selecting a water for a town supply, due regard should be had to colour—the lighter it is the better. The very brown waters are usually much objected to, even when it is known that the colouring matter is derived from peat, and is therefore comparatively innocuous. When water is impounded in reservoirs it often happens that its colour gradually becomes deeper; this change is due to the vegetable matter of the soil and of the reservoir becoming soluble and entering into solution. After a time, which may be from one to three years, the water will lose much, perhaps nearly all, its colour—this has happened in the case of the Vartry and Knockaderry (Waterford) waters. The nearer the amount of solid matter approaches that contained in the Vartry water the better—it is undesirable that it should exceed 14 grains per gallon.

It is most important to ascertain carefully the extent of the drainage area proposed to be utilised for a water supply, and also the rainfall of the district where several sources are available; that which yields the clearest water should be selected, so as to avoid the expense of filtration. The greatest attention should be given to the nature of the industries carried out upon the drainage area. If there be no factories or arable farms so much the better. If there be villages or even isolated dwellings, the sewage from which would probably enter a projected reservoir, the means of diverting such objectionable matter should be considered before the commencement of operations. It sometimes happens that the sources of impurities on a catchment area are so numerous and serious that they cannot, economically, be satisfactorily dealt with.

As a rule, I do not like supplies of water taken from large

rivers: I prefer the collection and impounding of springs and streams in hilly regions. In the former case the water, as a rule, has to be pumped up into "service reservoirs," which is more or less an objectionable process; in the latter case the water can be delivered, by its gravitating power, with any desirable pressure, to the points of consumption. Lakes, especially those of large size, afford in general better water than rivers. A little sewage entering the former has an inappreciable effect upon its composition, whilst upon a river its effect might for a time be very serious.

Springs in the limestone rocks often afford an abundant supply of water; it is usually hard, but this is generally its only bad point. The spring waters may be conveyed by means of small earthen or iron pipes (even gas pipes, as Sir Robert Rawlinson suggests, may answer) direct to small towns. In cases where there is a river ascertained to be free from pollution, its waters might be delivered under pressure, if pumped into tanks by means of turbines. These machines, so much used in America and other countries, are rarely employed in Ireland. It is not desirable to have the service tank placed in or very close to a town, as its water is liable to become contaminated with soot and other matters.

For many small towns a good supply might often be procured at a moderate cost. For example, Professor Townsend, C.E., has supplied Belmullet with high-pressure water at a cost of only £1,000, exclusive of the cost of land and legal expenses. The reservoir consists chiefly of concrete. The water flows by gravitation through an iron main.

In collecting water for the purpose of having it analysed, care should be taken to secure a specimen likely to represent the average quality of the proposed supply. The centre of a river is the best part to take samples from. If the water of a river is proposed to be taken as a supply for a town, then that of every neighbouring stream entering it should be examined. In case the analysis of one or more of the tributary streams proved unfavourable, it might often be possible to either divert the streams or take water from the river at a point above the objectionable tributaries to it.

I have discovered the remarkable fact that good and bad water may co-exist in the one well—good hard water at the lower part, soft and bad water on the surface. Hence it is important that surface drainage, nearly always polluted, should be kept out of the openings of wells by having them covered, and the sides of the shafts cemented at least six feet downwards.

The organic matter in water may be wholly or partially derived from a vegetable source such as peat, the decomposing roots, &c., of plants in the soil, and their decaying leaves, &c., lying upon the surface of the ground. In countries where malarial fevers prevail, the presence of much vegetable matter in potable water is likely to produce disease in those who drink it; but in Ireland there is no evidence to show that organic matter altogether derived from peat, &c., is injurious to health. This question is of great interest in this country where peaty waters are so very common. Those waters have a yellowish or even brown hue, and are more frequently soft than hard.

Vegetable matter contains, on the whole, nearly 2 per cent. of nitrogen; when dissolved or suspended in water, a portion of this nitrogen is converted by fermentation into ammonia, which ultimately becomes oxidised into nitric acid. In the statement of the results of a water analysis, the amounts of albuminoid ammonia and saline ammonia are always mentioned, and sometimes the amount of nitrogen in the form of nitrous and nitric acids. The albuminoid ammonia does not actually exist in the water, but is formed in it by the analytical process—a better term, sometimes used, is albuminoid, or organic nitrogen. The greater the proportion of this ingredient the worse the water, for the presence of a large quantity of nitrogenous organic matter is dangerous, whilst practically no amount of actual ammonia or nitric acid is injurious. Nevertheless, we do not like to find much saline ammonia in a water, as it generally indicates the presence of sewage. In a peaty water the albuminoid ammonia is often twenty times more abundant than the saline; but when sewage is present, the saline ammonia usually exceeds in quantity the organic ammonia. It is easy to understand why this should be so. The peaty matter in water slowly decomposes, whilst the urea which is usually present in sewage, and contains 47 per cent. of nitrogen, speedily becomes carbonate of ammonium. I often meet with a peaty yellow water containing per Imperial gallon—

Albuminoid ammonia	...	...	0·020 grain.
Saline ammonia	...	...	0·001 ,,

whilst in a bright and sparkling water we may often have per gallon—

Albuminoid ammonia		...	0·008 grain.
Saline ammonia	...	...	0·012 ,,

I should much prefer to drink the former water, notwithstanding

its flat flavour and yellow hue; for in the bright and colourless water the albuminoid matter would probably be derived from an animal source, and possibly contain the germs of a contagious disease.

In some waters large amounts of nitric acid are present. This is especially the case in the wells sunk in the carboniferous rocks. The nitric acid is generally derived from the oxidation of vegetable matter, and, but to a limited extent, from manure. By filtration throughout large masses of soil the water is purified from organic matters, but it contains the products of their decomposition. I prefer a water free from nitrates, and derived from untainted sources; but in certain districts we must tolerate the nitrates, if the water present no other objectionable features.

Chlorine, in the form of common salt, is present in water polluted by sewage, but it is often found in large proportions in really good water. The significance of chlorine has been much exaggerated. In hard and good water it is often present to the extent of from 4 to 10 grains per gallon. Frequently it exists as magnesium chloride or calcium chloride.

It is desirable that the amount of albuminoid ammonia should be less than 0·01 grain per gallon, and of saline ammonia less than 0·008. In the best waters the albuminoid and saline ammonia are low down in the third decimal place.

In 1881 there were in Ireland eleven cities and towns governed by Corporations, or Town Councils. Their aggregate population amounted to 683,502, and their valuation to £1,743,317. Their revenues amounted to £794,625.*

The nine townships surrounding the city of Dublin had a population of 95,400, a valuation of £390,667, and a revenue of £63,219.†

There were 92 cities and towns governed by Towns' Commissioners; their population amounted to 434,138; their valuation to £671,153;‡ and their annual revenue to £103,527.

The population of all these towns was therefore in 1881, 1,213,040, and their valuation for rating amounted to £2,805,137. In Irish towns the valuation is about two-thirds of the actual letting value.

I have endeavoured to ascertain the nature of the water

* These figures (with some corrections) I have taken from Thoms' Directory for 1884, pages 668 to 670.

† Exclusive of Drumcondra township, for which I have no return.

‡ Exclusive of Auchnacloy, Belturbet, Castleblayney, Cootehill, Fethard, Keady, Rathkeale, Tandragee. Their town revenues amounted in 1881 to £736.

supplies to these 112 cities, towns, and townships. The following is a brief summary of the facts ascertained:—

The Eleven Towns Governed by Town Councils.

Belfast.—Population, 207,671; valuation £568,137. The water is almost wholly supplied from a reservoir, situated near Carrickfergus, about twelve miles from Belfast. The pressure is good, and the reports upon the quality made by Dr. Hodges, of Belfast, are satisfactory. It contains 12·6 grains of solid matters per gallon, and 0·11 part of albuminoid, and 0·07 part saline ammonia per million parts. These figures show that it is not equal to the Dublin pipe waters.

Clonmel.—Population, 10,519; valuation, £15,424. Supplied by local pumps and wells. I have from time to time examined a large number of specimens of the water used in this town. On the whole, they have not been of the quality suitable for domestic purposes. As a rule they were exceedingly hard, containing nearly 100 grains of solid matters per gallon. A few were highly polluted with sewage. The waters from Clonmel which I have lately analysed, were purer, probably because their sources were better protected from pollution. A town so large as Clonmel should be provided with a good supply of water, obtained from some of the neighbouring high grounds.

Cork.—Population, 78,361; valuation, £226,022. The supply of water is obtained from the River Lee, at a point about a mile above the city. Mr. O'Keefe's (Public Analyst for Cork) analysis of the water, made some years ago, did not give favourable results. He found that an imperial gallon contained—total solids, 5·57 grains, including albuminoid ammonia, 0·075 grain; saline ammonia, 0·04 grain; and chlorine, 0·661 grain. These figures indicate pollution. Since this analysis was made the waterworks have been improved, and the water is now filtered properly. Still, a water-supply from a river bordered by towns is not a desirable one. I think the sewage of Macroon enters the river at a point twenty-seven miles above the city of Cork.

Drogheda.—Population, 12,516; valuation, £28,121. This town is supplied partly with pressure water obtained from a Waterworks Company and partly by local pumps. The pipe water is collected at a gathering ground about two miles distance from the town, and stored in a reservoir. It is a fairly good water, but not equal to the pipe water of Glasgow and Dublin. It contains about 13 grains of solid matter per gallon, and from 0·005 to 0·01 of albuminoid ammonia, and somewhat smaller quantities of saline ammonia. In winter the supply is abundant, but in summer it is so scanty that the supply to the houses is limited to two hours daily. A small reservoir, situated one mile from the town, supplies two fountains. Sixteen of the local pumps are in possession of the Corporation. I have analysed the water yielded by all of them. They are mostly free from sewage; but the greater number are too hard for washing with, or, indeed, for any purpose save flushing sewers, &c. Perhaps the Corporation might see their way towards purchasing the waterworks and extending them. The water supplies of towns should always be under the management of the governing bodies thereof.

Dublin.—Population (of City), 249,486; valuation, £657,820. The gathering ground of the water supplied to Dublin consists of mountains, chiefly of the lower Cambrian formation, situated about 26 miles from the city, in the County of Wicklow. The reservoir is very large, and is capable of supplying 35 gallons per diem per unit of the population. At first the water impounded had a faint yellow colour, which gradually became deeper, and after three or four years became so deep as to excite alarm. The colour was caused by the peaty and other organic matter in the reservoir becoming soluble by fermentation. After a time the hue became less intense, and now the water is almost colourless. It is soft; one imperial gallon contains about 4·5 grains of solid matters, 0·005 grain of albuminoid ammonia, 0·0008 grain of saline ammonia, faint traces of nitrates and nitrites, and 0·96 grain of chlorine. Its hardness is about 1·8°, of which 0·8 is permanent. It is one of the purest waters in the world. With respect to pressure and quantity, the citizens have nothing to complain of. The cost of the work was £640,682 10s. 2d., up to 1884.

There are some well waters still used in Dublin. They are generally very hard, owing to the presence of large quantities of earthy salts. I have often found in Dublin pump waters from 50 to 75 grains of calcium sulphate per gallon. I consider most of these waters unfit for use, but there are some exceptions, notably the pump water in the Bank of Ireland. This water has the following composition per gallon:—

	Grains.
Total solid matters	24·500
Including	
Albuminoid ammonia	0·004
Saline ammonia	0·003
Nitrogen in nitrates and nitrites	0·090
Calcium sulphate	4·420
Chlorine	2·491
Oxygen required to oxidize organic matter...	0·208
Hardness	1·8°

Kilkenny.—Population, 12,182; valuation, £33,155. This city is supplied by local wells, and, also to a limited extent, from a river. I have analysed, I think, the water from all the public and from many of the private pumps. There is no pressure water. The water from the wells is exceedingly hard, owing to the presence of lime and magnesia salts. They contain from 50 to more than 100 grains of solids per gallon. The majority are free from actual sewage; but as a rule they contain extremely large quantities of nitric acid—a product of the decomposition of nitrogenous organic matter. The sources of the water are, as a rule, tainted; but the water as taken from the wells is in general so well filtered by passage through a calcareous soil that it is generally very free from organic matter. Some are, however, more or less polluted. Kilkenny is one of the Irish towns which most urgently require a good water supply.

Limerick.—Population, 38,600; valuation, £65,547. This city is supplied with pipe water taken from the river Shannon, about 1½ miles distant from the city. For many years the quality of the water has been complained of, owing chiefly to its great turbidity, for the water was not filtered. The Corporation have recently purchased the waterworks from a Company. It may be that the water supply to the city will still be taken from the Shannon, but I am of opinion that a better quality of water is procurable in sufficient quantities from drainage areas in the high grounds not very distant from the city. I have analysed several samples of water proposed to be supplied to Limerick, and consider them much superior to the Shannon water. Many of the local wells are still in use, but as a rule they furnish impure water.

Londonderry.—Population, 28,947; valuation, £74,595. High-pressure water is supplied from reservoirs situated outside the city. The quantity is insufficient for a constant service, but the Corporation propose to procure an increased supply. Prof. Leebody's analysis shows that the water is of good quality. It is soft, containing 9½ grains of solids per gallon. It is delivered unfiltered.

Sligo.—Population, 10,764; valuation, £18,619. This town will soon be supplied with pressure water of good quality and soft, taken from a reservoir situated five miles from the town. Estimated cost of the work, £28,000.

Waterford.—Population, 22,401; valuation, £39,866. Until very recently this city was wholly dependant upon local pumps, the water from which was, with few exceptions, of extremely bad quality. The worst water which I have, I think, ever analysed came from a largely used public pump in this city.

This water contained per gallon in grains—

Solid matters	385·8
Including	
Albuminoid ammonia	0·4
Saline ammonia	1·5
Sodium chloride	76·0
Calcium sulphate	34·0

The amount of ammonia in this water exceeded that often present in sewage.

A few years ago a new supply of water was obtained by impounding the drainage of a hilly region at Knockaderry, ten miles from the city. The water proved to be extremely brown in colour, which circumstance created great dissatisfaction amongst a large section of the citizens, some of whom refused to use the water. I predicted that in the course of a few years the hue of the water would be much less deep. The last specimen sent to me for examination, though still somewhat coloured, was comparatively pale as compared with the specimens sent to me three or four years ago. The citizens now seem satisfied with the water. The cost of the waterworks, &c., was £77,000.

Wexford.—Population, 12,055; valuation, £16,011. I have analysed several specimens of pump water used in this town. The majority were soft and fairly good, but several were hard and bad. One contained 95·2 grains of solid matter per gallon. A high-pressure supply of good water was lately procured. The waterworks have cost £30,000.

The Dublin Townships.

These districts are, with the exception of a very small portion of their area and exclusive of Rathmines, supplied with the Vartry pipe water (the same as that furnished to Dublin). Rathmines township is at present supplied with water from a canal. It is hard and of somewhat doubtful purity. The township will, however, soon be supplied with soft and remarkably pure water collected from the Dublin mountains.

The 92 Towns under Towns Commissioners.

Antrim.—Population, 1,647; valuation, £3,554. Supplied with pump water of, it is believed, good quality and palatable. The "Six Mile" river which flows past the town supplies water for various purposes.

Ardee.—Population, 2,622; valuation, £4,060. The water is derived from pumps and wells. The quality is believed to be fairly good, but no analyses of it have I believe been made.

Armagh.—Population, 10,070; valuation, £16,925. A high-pressure supply from a small lake two and a half miles from the city was procured some time ago. It is rather peaty, and when in summer the lake falls considerably, the colour is somewhat high. On the whole, however, the water supply of this city is fairly good.

Athlone.—Population, 6,755; valuation £9,671. This town is supplied with water from the Shannon, which flows through it. There are seven pumps attached to wells. The water supplies are on the whole fairly good.

Athy.—Population, 4,181; valuation, £5,680. I have examined a great number of the well waters, which furnish exclusively the supply of this town. About one-third were very much polluted, and the rest were first or second class waters. Some of the pump waters in this town contain about 100 grains of solids per gallon. This town requires an improved water supply.

Auchnacloy.—Population, 1,333; town revenue, £77. The town is supplied by wells, one of which is much used by the poorer inhabitants, though the water is impure.

Bagenalstown.—Population, 2,141; valuation, £3,414. The supply of water is from local wells and a river. Some of the well waters are fairly good, others are of indifferent quality. Some of the water is filtered.

Balbriggan.—Population, 2,443; valuation, £4,014. The water is derived from wells and pumps. It is far too hard for potable purposes, and in some instances it is otherwise impure.

Ballina.—Population, 5,760; valuation, £8,154. This town will soon be supplied with high-pressure and good water from Loch Brohly, six miles distant. Prof. Townsend, C.E., informs me that the contract for executing the works was £8,556; this was exclusive of law costs. The supply will be 20 gallons per head.

Ballinasloe.—Population, 4,772; valuation, £8,740. The town is supplied wholly from local wells, some of which yield an inferior water.

Ballybay.—Population, 1,654; town revenue, £142. This town has an insufficient supply of water, which, moreover, is of very bad quality. It is derived chiefly from wells; but a small river yields water which is much used, though it is known to be highly polluted.

Ballymena.—Population, 8,883; valuation, £21,423. I have analysed twenty-one of the well waters of this town; with some exceptions they proved to be hard and fairly good. One of

these waters contained 137·9 grains of solid matters per gallon, including the enormous quantity of 37·64 grains of nitric acid. Another contained 136·5 grains of solids, including 19·11 grains of nitric acid. An improved water supply from a distance of about seven miles is now being procured at a cost of £23,000.

Ballymoney.—Population, 3,049; valuation, £6,034. The supply is taken from local pumps, and is deficient in both quality and quantity. But a good high pressure water will soon be supplied to all the houses in the town at a cost of £6,000.

Ballyshannon.—Population, 2,840; valuation, £4,022. The supply is from pumps and wells. I have analysed only one water from this town, and it proved to be a good one; but the inhabitants are disatisfied with their water supply, and the question of improving it has lately been considered.

Banbridge.—Population, 5,609; valuation, £12,716. I have examined about 40 well waters used in this town. Most of them are very hard, and several are polluted with sewage. This town urgently requires an improved water.

Bandon.—Population, 5,945; valuation, 9,621; town revenue (1881), £1,890. Supplied by wells and pumps. One of the waters which I examined was hard, but otherwise good. A scheme for supplying the town with high-pressure water is now under consideration, and the proposed water is being analysed in my laboratory.

Bangor.—Population, 3,006; valuation, £10,287. Works to supply high-pressure water are nearly completed. They will cost about £10,000. I have analysed the water proposed to be used, and have found it to be of good quality. I have found the pump waters of this town to be superior to average well waters.

Belturbet.—Population, 1,807; town revenue, £375. The river Erne and three pumps furnish the water. One of the pumps yields a supply of very doubtful quality.

Boyle.—Population, 2,994; valuation, £3,847. The town is supplied with well waters only. Those that I have analysed proved to be fairly good.

Bray.—Population, 6,535; valuation, £24,503. This town is supplied with good high-pressure water.

Callan.—Population, 2,340; valuation, £2,002. Supplied by local pumps, some of which are of doubtful quality.

Carlow.—Population, 7,185; valuation, £11,157. The town depends upon local wells for its supplies. I have analysed many of the waters used in this town, and, on the whole, have an unfavourable opinion of them. Many of them contain from 70 to 112 grains of solids per gallon, including from seventeen to twenty-two grains of nitric acid. The rise of the River Barrow appears to affect the quality of the Carlow well waters. The town urgently needs a good supply of high pressure water.

Carrickfergus.—Population, 10,009; valuation, £5,561; revenue, £1,275. The town is supplied with good water from reservoirs, situated one and a half miles from the town.

Carrickmacross.—Population, 2,002; valuation, £2,893. This town is supplied by well waters, several of which I have analysed and found to be impure.

Carrick-on-Suir.—Population, 6,583; valuation, £8,836. This town has no pressure water. Some of the well-waters which I have examined are of good quality.

Cashel.—Population, 3,961; valuation, £5,695. A good supply of pure water of high-pressure is obtained from the neighbouring hills; it is filtered before being delivered to the city, for this small but ancient place is entitled to the rank of city.

Castlebar.—Population, 3,855; valuation, £4,132. The town depends upon wells and pumps; the water from them is, as usual in such towns, not alogether pure.

Castleblayney.—Population, 1,810; town revenue, £100. Supplied by local wells and pumps. The water is believed to be fairly good.

Cavan.—Population, 3,050; valuation, £5,155. The results of analyses of fifteen of the pump waters in this town enable me to state that Cavan is one of the towns in this country most urgently requiring good water. There are hills not far distant from which supplies might be procured.

Clonakilty.—Population, 3,676; valuation, £4,824. Supply of good water, gathered from neighbouring hills, is delivered under pressure to the town.

Clones.—Population, 2,216; valuation, £3,356. The supply is chiefly from five public pumps, two of which are adjacent to and below the level of church-yards. The Local Sanitary Authority (the Board of Guardians) has hitherto not complied with the oft expressed request of the Town Commissioners for a more abundant and purer supply of water.

Coleraine.—Population 5,899; valuation, £12,805. This town is supplied with water collected from springs situated about three miles distant. It is conveyed direct from the springs, and has a considerable degree of pressure. In case of a contingency water may be also obtained from a small reservoir which contains sufficient for fourteen days' supply. Fifty gallons per head is the quantity delivered. The water contains $11\frac{1}{3}$ grains of solids per gallon, and is very free from organic matter. I have analysed two specimens of pump water from this town and found them to be of good quality. The waterworks of this town have cost £9,600.

Cookstown.—Population, 3,870; valuation, £6,187; town revenue £189. This town has no high-pressure water. Fifteen public and several private pumps supply water, concerning which local opinion is much divided. Some of the townspeople are satisfied with its quality; others considered it for the most part impure. In 1876 seven of the waters used in this town were submitted to me for analysis. I found that they were free from sewage. The total solids varied from 8 to 45 grains per gallon. Professor Hodges has, however, found impurities in some of the pump waters. Some of the waters which I have examined are undoubtedly too hard. The subject of obtaining a supply of good high-pressure water has long been discussed. A scheme for this purpose was proposed in 1876 by Mr. J. F. Mackinnon. He proposed to take water from Loughbrackin, a distance of seven and a half miles. The cost was estimated at £8,430. He proposed another scheme for taking water from Mountober Springs, situated four and a half miles from the town. This scheme, which involves the construction of a reservoir, would cost as estimated £12,500.

Cootehill.—Population, 1,789; town revenue, £152. The town commissioners have control of five pumps which supply, very inadequately, the wants of the town. Many private wells and some small streams are brought into requisition to make up the deficiency. Some of the pump waters are very inferior, and the town ought to be provided with a good and sufficient supply.

Downpatrick.—Population, 3,419; valuation, £8,001. Some of the pump waters in this town are exceedingly hard, and some are impure.

For several years past the Downpatrick Board of Guardians have been discussing schemes for supplying the town with pure water, but though much expense has been incurred by them in commissions, &c., the supply is still wanting.

Dromore.—Population, 2,491; valuation, £4,363. I have lately analysed nine waters from the public supplies in this town. Several of them were very hard and impure, and most of the others were second-class waters.

Dundalk.—Population, 11,913; valuation, £20,692. The pump waters in this town are on the whole of very inferior quality; a good supply of almost colourless water will, however, soon be procured from neighbouring hills. It is one of the purest waters that I have ever examined. A loan of £26,000 for waterworks has been secured.

Dungannon.—Population, 4,084; valuation, £8,114. A high-pressure supply is procured from a distance of seven and a half miles at a cost of £13,500. It is of good quality.

Dungarvan.—Population, 6,306; valuation, £8,265. All the pump waters sent to me from Dungarvan prove to be free from pollution.

Ennis.—Population, 6,307; valuation, £6,944. The well waters in this town are, as a rule, very impure. One of the town pumps was closed by order of the magistrates some time ago, on the application of the local authorities. My analysis proved that the water was largely composed of sewage. Ennis has lately been supplied with pressure water from a neighbouring reservoir connected with a lake. The cost of this improvement has been £11,000. It is slightly peaty, but good in all other respects.

Enniskillen (population, 5,712; valuation, £11,714) is supplied with high-pressure water, taken from Lough Erne at a point distant four and a half miles from the town. The lake has an area of 36,923 acres, and its waters ought to be pretty pure, but as supplied to the workhouse I found it rather yellow. It contained 7·7 grains of solids per gallon. The pump waters of Enniskillen are not, as a rule, very good. The water rate is 6d. in the pound on the Poor-law valuation.

Fermoy (population, 6,454; valuation, £9,931) will soon be supplied with good high-pressure water from a reservoir situated three and a half miles from the town. The works will be completed at a cost of £13,000.

Fethard (population 1,926; town revenue, £168) is supplied by four public and several private pumps. One of the pumps yielded water which I found to be very impure.

Galway.—Population, 15,597; valuation, £26,240. High-pressure water is supplied from the river Corrib, which discharges the waters of a large lake—Lough Corrib—into the sea. The water contains about 11 grains of solids per gallon, 0·008 grain of albuminoid ammonia, 0·002 grain of saline ammonia, and 1·4 grain of chlorine. Hardness 7°. It is, therefore, a fairly good water, but not equal in colour or purity to the Dublin pipe water. The pump waters in Galway are all hard, from presence of lime and magnesia salts, and some of them are somewhat impure.

Gilford.—Population, 1,324; valuation, £1,834. Supplied by local wells, the water of which is pretty good.

Gorey (population, 2,450; valuation, £3,148) is supplied with high-pressure water of good quality, but, so far as 1884 is concerned, deficient in quantity. One spring supplies a reservoir, and water from other springs is conveyed direct to the town.

Holywood.—Population, 3,293; valuation, £12,480. This town was, in 1883, supplied with water collected at a distance and delivered to the town under pressure. My analysis shows that it contains 14 grains of solid matter per gallon, including 0·005 grain of albuminoid ammonia; saline ammonia, 0·006; nitrogen in nitrites and nitrates, 0·015 grain; chlorine, 1·886. The water is nearly colourless. Cost of the waterworks, £10,000.

Keady.—Population, 1,598; town revenue, £253. The public fountains and some of the houses are supplied with high-pressure water from a reservoir in connection with Clea lake. Dr. Allen, Chairman of the Town Commissioners, informs me that some of the well waters still used are scarcely fit for potable purposes. Several of the wells dried up this year.

Kells.—Population, 2,822; valuation, £3,508. The water is derived from pumps and wells. It is mostly very hard, and some of it impure.

Killarney.—Population, 6,651; valuation, £4,928. Many of the pump waters in Killarney are soft and pretty good, but several are very impure. A supply of good soft water will soon be collected from a stream from neighbouring hills and stored in a tank. The cost is estimated at £8,000.

Kinsale.—Population, 5,386; valuation, £5,454. I have examined a pretty fair specimen of water for the Kinsale Harbour Commissioners. This is all the knowledge which I possess of the water supplies of this town.

Larne.—Population, 4,716; valuation, £4,782. This town has just been furnished with a supply of water from the "Sallagh" Springs, situated on elevated ground three and a half miles from the town. The water is good and abundant. There is a tank, but the water in it is intended to be used only in case of fire.

Letterkenny (population, 2,188; valuation, £3,215) was long dependent upon the scanty and impure supplies of water furnished by local wells, but now it has abundance of good water, obtained from a distance. The main reservoir is one mile from the town.

Limavady (population, 2,954; valuation, £5,795) is supplied with high-pressure water from a tank having a capacity of 135,000 gallons. The water is good, and is collected from springs. The works will cost £6,000.

Lisburn.—Population, 10,753; valuation, £18,751. The greater part of the town is supplied with pressure-water from a reservoir one mile distant. Its composition, according to Dr. Hodges, is as follows:—Total solids, 12·6 grains per gallon; albuminoid ammonia, 0·199 parts per million; saline ammonia, 0·055 parts per million. The quantity of albuminoid ammonia appears to be excessive. In the outskirts of the town the people depend upon wells.

Lismore.—Population, 1,860; valuation, £2,212. Is supplied with high-pressure water brought direct from springs in the clay slate rocks, lying north of the Blackwater. The water is very good, but in summer it is occasionally deficient, and fails to supply the houses in the higher parts of the town. The supply is usually turned off at night. Lismore, therefore, requires an improved water supply.

Longford.—Population, 3,590; valuation, £7,029. I have analysed several of the pump waters, and found the greater number to be impure.

Loughrea.—Population, 3,072; valuation, 3,665. The water used is chiefly taken from a neighbouring lake, and is delivered with some degree of pressure into many of the houses. My analysis of the water as supplied to the town shewed that it had in some way become somewhat polluted. The water supply to Loughrea requires investigation. The water is pumped by turbines into a tank, having a capacity of 118,000 gallons; the cost of the works was £3,370.

Lurgan.—Population, 10,135; valuation, £18,348. The water used in this town is derived from public pumps and private wells. Its quality varies considerably; several specimens which I analysed proved to be impure; one contained 113 grains of solids per gallon.

Mallow (population, 4,439; valuation, £6,478) is famous for its springs and spas; yet in some parts of the town the pump waters are very impure. When Asiatic Cholera visited this town it was in the quarters where the impure water was used that the disease was most prevalent. The town is supplied with pressure water from a reservoir at a cost of £6,250.

Maryborough.—Population, 2,872; valuation, £3,869. The water, derived from wells and pumps, is extremely hard, but generally free from sewage impurities.

Middleton.—Population, 3,358; valuation, £5,675. The waters in use in this town are deficient in quality and quantity. The Board of Guardians have undertaken to supply the town with pure water.

Monaghan.—Population, 3,369; valuation, £5,967. Nine public pumps and numerous private wells and pumps supply water to the inhabitants. Some of the wells are 50 feet deep. In most cases the water is pure.

Mountmellick.—Population, 3,126; valuation, £4,052. Excessive hardness is the characteristic of the well waters which supply this town. Although some of them are free from pollution, others are not so, and on the whole I think Mountmellick requires an improved water supply.

Mullingar.—Population, 4,787; valuation, £7,541. I have examined a large number of the pump waters which supply this town. Some of them are fairly good, but others are hard and bad. In one I found 137 grains of solid matters per gallon, including the very high proportion of 0·05 grain of albuminoid ammonia.

Naas—Population, 3,808; valuation, £7,612. Depends altogether upon local wells and pumps, many of which I have found to be very impure.

Navan.—Population, 3,873; valuation, £5,660. The town depends altogether upon supplies from local sources, which have no pressure. There are nine public pumps and many public and private wells, including a so-called spa. Some of these waters are good though somewhat hard for detergent purposes, others are of indifferent quality; in one I found 119 grains of solid matters.

The following are analyses of the water of the river Boyne, taken above the town, and of the Blackwater, taken in the town.

One imperial gallon (70,000 grains) of each contains—

	Boyne. grains.	Blackwater. grains.
Total solid matters	19·600	13·300
Including		
Albuminoid ammonia ...	0·012	0·012
Saline ammonia	0·002	0·002
Nitrogen acids...	traces	traces
Chlorine	0·980	0·985

The Blackwater, filtered, would furnish a better quality of water to Navan than it obtains from the local wells.

Newbridge.—Population, 3,372; valuation, £4,325. The pump waters which supply this town are exceedingly hard. In four of them I found more than 200 grains of solid matters per gallon. They are, however, pretty free from actual sewage matter.

New Ross.—Population, 6,670; valuation, £8,039. Four conduits convey water from springs situated in the higher portion of the town, and delivered with some degree of pressure to the lower portions of the town. In 1877 I found the water from the principal tank was fairly but not very good. There are six public pumps which also supply water to the town, their quality is variable; as a rule the New Ross waters are pretty soft.

Newry.—Population, 15,096; valuation, £32,450. This important town is supplied with water taken from the Lake of Camlough, which covers an area of 160 acres, and is situated at a distance of four miles from the town. 650,000 gallons are delivered at a very high pressure, and the great majority of the houses have the water laid on to their interiors. There are numerous street fountains for the use of the poorer classes. The composition of the water is somewhat variable, but on the average it contains about eleven grains of solid matters, and very moderate amounts of albuminoid and saline ammonia. Newry is, therefore, one of the few towns in Ireland provided with really good and abundant water.

Nenagh (population, 5,422; valuation, £8,312) is altogether supplied by well and pump waters. I have not examined many of them, but the few which have come under my observation have been pretty good.

Newtownards.—Population, 8,676; valuation, £10,005. I have made a very large number of analyses of the water used in this town. Twenty-two of the pump and well waters were analysed in 1877; of these seven were unfit for use, and some of the others were second-class. The solids in solution varied in amount from 15·4 to 91 grains per gallon. Eighteen specimens analysed in 1881 were of better quality, their worst features being excessive hardness, and the presence of much nitric acid. Three pump waters examined in 1882 were fairly good.

Omagh.—Population, 9,755; valuation, £6,251. Pressure water is supplied to this town. Its composition I found, in 1882, to be as follows:—

One Imperial gallon contained—

Total solid matters	4·900 grains.
Including—	
Albuminoid Ammonia ...	0·006.
Saline Ammonia	0·004.
Nitrogen Acids	traces.
Chlorine	1·415.

The water is derived from a reservoir two and a half miles distant from the town. Amount of waterworks loan, £12,115.

Parsonstown.—Population, 4,126; valuation, £8,712. Has only pumps and open wells to procure water from. These waters are very hard. Some of them are free from organic impurities; others are polluted. In one I found 111·15 grains of solids per gallon.

Portadown.—Population, 4,955; valuation, £17,066. Supplied by local wells. In one of their waters I found 114 grains

of solids and 30 grains of chlorine. It was, however, free from sewage; others examined by Dr. Hodges and the late Mr. Whitla were, with one exception, found to be pretty good.

Queenstown.—Population, 9,755; valuation, £19,908. This town has just secured an excellent supply of water from a distance of about eight miles, and at a cost of about £20,000. I have analysed the water, and found it to be very pure.

Rathkeale (Population, 2,549; revenue, £192) is supplied with pump water only, which on the whole appears to be of fairly good quality.

Roscommon.—Population, 2,117; valuation, £2,880. Supplied only by pumps, the water from which is pretty good.

Strabane. — Population, 4,196; valuation, £9,187. Has a high-pressure supply, but the quantity is most defective, the town may be said to be really badly off for water.

Skibbereen.—Population, 3,631; valuation, £4,699. The springs and wells which supply this town are deficient in quantity, and some of them in quality, during the recent hot weather the springs almost disappeared. The Board of Guardians—the Sanitary Authority—have undertaken to improve the water supply of this town, but up to the present have not realised their promises.

Tanderagee.—Population, 1,592; town revenue, £56. Four water pumps supply this town. I have analysed three of them: 1 was bad, 1 good, and 1 indifferent.

Templemore.—Population, 2,800; valuation, £3,886. Has a rather scanty supply, of indifferent quality of pump and well waters.

Thurles.—Population, 4,850; valuation, £6,107. Local wells supply the water used for potable purposes, and for other purposes the River Suir is made available. One of the well waters sent to me for analysis in June last was very hard (105 grains solids per gallon), one was slightly polluted, and another specimen was found to be pure.

Tipperary. — Population, 7,274; valuation, £8,663. The town is supplied by a spring termed the Church Well (which has not failed during the recent drought) and several public and private pumps and wells. Several of the waters are very hard; one contains 137·9 grains of solids per gallon, and is somewhat impure. Yet on the whole this town is pretty well supplied with water, which, however, has the disadvantage of not being delivered under pressure. The water used in the barracks was analysed in 1877 at Netley, by Prof. De Chaumont, and found to be "usable."

Tralee.—Population, 9,910; valuation, £12,303. The well waters of this town are generally unfit for use. I have analysed about 30 of them. Some contain from 100 to 200 grains of solid matters per gallon. Recently a supply of water from a tank situated 4½ miles from the town has been procured, and it has been conveyed under high pressure into many of the houses in the principal streets.

The composition of this water, according to my analysis, is as follows. I give it as an example of really good water:—

One imperial gallon (70,000 grains) contains:

Dissolved.	Grains.
Lime	0·24
Magnesia	0·11
Potash and soda	0·69
Oxide of iron, silica, &c.	0·28
Chlorine	0·68
* Organic and volatile matters	2·50
Total solid matters per gallon ...	4·00
* Including organic nitrogen	0·004
" ammonia	0·002
Nitric acid	Faint trace
Nitrous acid	None

Matters Suspended in the Water.	
Organic and volatile (at a red heat)	0·55
Fixed solids	·17
Total suspended matters	·72

One gallon of this water, therefore, contains, of solid substances:

	Grains.
Suspended matters	0·72
Dissolved matters	4·00
Total solid matters	4·72

Of the solid substances 0·86 grain is precipitated by boiling a gallon of the water for ten minutes.

Trim.—Population, 1,586; valuation, £2,115. The town has no pressure water. Many of the pump and well waters are impure, two of the public pumps were closed by order of the sanitary authorities, my analysis having shown that they were unfit for use.

Trim has, for a small town, a very large revenue, namely, about £800 a year. Good water is procurable from springs situated near the town. There would, therefore, seem to be no good reason why this town should not be supplied with pure water.

Tuam (population, 4,223; valuation, £4,035) is supplied by pumps and wells, and their waters are "good, bad, and indifferent," as is usually the case in such towns. In a water sent to me from this town by Mr. French, solicitor, there were 164 grains of solids per gallon, and in other respects the water was bad.

Tullamore.—Population, 5,098; valuation, £5,392. The water supply is derived from five public pumps, and from private pumps and wells. It is generally very hard, but on the whole free from pollution.

Westport.—Population, 4,469; valuation, £6,243. The town is supplied by wells and pumps. Their waters are generally somewhat peaty, but free from sewage.

Wicklow.—Population, 3,391; town revenue, £1,361. The majority of the pump waters in this town are impure or second class. A pressure supply has lately been procured. The reservoir is about one mile from the town. The water is of good quality though somewhat high in colour, but no doubt, as in similar cases, the colour will in time become less intense. The waterworks cost about £6,000.

Youghal.—Population, 5,936; valuation £9,571; town revenue, £2,144. Four public pumps and several private wells supply the inhabitants with water. The quality is locally believed to be good. I have not seen any analyses of Youghal waters.

In concluding these brief notices of the supplies of water to Irish towns, I have to point out that, as a rule, they are of defective quality, and that in the great majority of cases the towns of Ireland have no high-pressure water, which is so useful in the case of fires and for other purposes. The Metropolitan area and eight of the towns governed by Corporations have high-pressure water supply, but very many of the 94 smaller towns are dependent upon local wells, &c., which, on the whole, furnish impure supplies.

[*For discussion on this Paper see page* 389.]

On "*The Supply of Pure Water to Villages and Country Residences in Ireland*," by Prof. Hull, LL.D., F.R.S.

The importance, in relation to health, of pure water for domestic use, though generally recognised in theory, is often neglected in practice. To the existence of an impure water supply may often be traced the outbreak of typhoid or other zymotic fevers in villages and country houses, which might be supposed to be safe against the attacks of this and similar unwelcome visitants. Where cholera is prevalent, contaminated water is a prime cause of attack. Large towns are really in a better position as regards pure water-supply than villages and country houses, as, under the Public Health Act of 1872, the corporate bodies and sanitary boards have powers and means for procuring proper supplies of pure water which do not exist in the case of humbler and smaller centres of habitation. The City of Dublin, notwithstanding many disadvantages as regards its sanitary arrangements, possesses at least the inestimable blessing of abundance of pure water.

Some years ago I ventured to read a paper at a meeting of the British Association, at Bristol,* on the subject of the water-supply for villages and hamlets in England; in which I pointed out that, owing to the geological structure of the central and southern portion of that country, villages and hamlets now improperly supplied, might, by a system of deep wells, have pure water made available through local effort similar to that of the School Board system. The peculiarity of the geological structure of that country, on which I founded my proposals, lies in the alternation, or succession, of permeable and impermeable strata over very large areas; the permeable strata being water-bearing, the impermeable not so, or only to a slight extent. These proposals received the approval of the then President of the Local Government Board, Mr. Sclater-Booth, but have not as yet been acted upon. The principal water-bearing formations of England are the Chalk, the Oolitic limestones and sandstones, the New Red Sandstone, and the Permian formations.†

It is to be regretted that this country is not so favourably

* "A Scheme of Water-supply for Villages, Hamlets, and Country Parishes of the Central and Eastern Counties."—*Quarterly Journal of Science*, July, 1876.

† See also on this subject De Rance's work on the "Water-supply of England and Wales." (Stanford, London.)

circumstanced for local water-supply from deep wells as England. The formations of which it is composed throughout almost the whole of its area are of older date than those which in England afford the largest and most reliable supplies, such as the New Red Sandstone and Cretaceous beds*—they are harder, less absorbent, and less porous in structure; and consequently do not imbibe the quantity of rainfall that softer, and more porous, strata are capable of doing.

The great Carboniferous limestone formation, which occupies an area of one-half the surface of the country, is doubtless water-bearing in *this* respect:—that the rain passes down into, and through, it by means of fissures and joints; but it is not of the porous nature of the Chalk, which absorbs into its own mass a quantity of water equal to at least half the annual rainfall. Hence it is that sinking for water by means of wells in the Carboniferous limestone becomes an uncertain undertaking, as its success will depend on the well (or other perforation) striking a water-bearing joint or fissure. The same may be said of the Silurian and Granite Rocks, which are largely distributed along the east of Ireland, as may be seen by reference to a geological map.†

Thanks, however, to the abundant rainfall and to these same characteristics of the strata, springs are numerous, especially in hill districts; and if proper investigations are carried out, in most cases it will be found that, one or more springs of water are within reach of any special village or country residence, which only require to be tracked up to their source and conducted by closed pipes to the place of supply. Much detriment to health may arise from the use of water which, originating in a pure spring, has been allowed to flow to the place of supply subject to contamination from decaying animal or vegetable matter along its course. Earthenware pipes, properly laid two or three feet below the surface, and set in cement, will suffice to carry the water intact when there is a slight fall all the way.

In many cases, however, wells become necessary, and special precautions are required in order to obtain satisfactory results. In England, where the New Red Sandstone or Chalk formations prevail, wells for the supply of villages or private houses are often sunk to considerable depths, varying from 150 to 200 feet, or even more. In such cases they have to be carried down below the underground water-level, and draw their supplies from the internal reservoirs. Such wells always afford pure

* Some large and deep wells in these formations yield from one to two millions of gallons per day, raised by powerful pumping machinery. They are at work in Liverpool, St. Helens, Nottingham, Birmingham, &c.

† See appendix.

and wholesome water; because, being derived from the rainfall, it has necessarily percolated through a considerable thickness of rock, which acts as a natural filter for eliminating surface impurities. Such wells, however, are rare in this country. As far as my information goes, *deep wells* are almost unknown amongst villages and country houses, and supplies are generally drawn from shallow wells, small surface streams, or ditches.

This seems a fitting occasion to call attention to the danger to health which arises from the use of water from such sources. Water which comes from surface-drainage is liable to contamination from various causes, amongst which may be mentioned the manure used for agricultural purposes. Vegetable and animal matter is constantly decaying at the surface, and is liable to be taken up by surface streams. Therefore, it follows that, where pure spring water cannot be had, deep wells should be sunk for domestic use.

The Post-Tertiary, or glacial deposits which occupy a very large proportion of the surface of this country—offer facilities for supply from wells. These deposits are permeable; and consist of sand, gravel, silt, and stony clay. Of such deposits a very large part of the central plain of Ireland, as well as the valleys and plains of other parts, are formed; extending below the peat-bogs, or overspreading the surface where bogs do not exist. Wells sunk in these deposits are likely to yield wholesome water, but under the following necessary conditions:—

1. They should be of sufficient depth, not less than 35 or 40 feet; better if more.

2. The surface-drainage ought in all cases to be stopped off. This can be done by lining the well with brick or solid masonry, properly cemented, to a depth of about ten feet, below which the well need only be lined with rubble.

3. In no case should the well be sunk in a farmyard, or near a cesspool or manure heap; nor should it be in such a position that it would receive the water percolating from any source of contamination of this kind. Even a water-tight lining such as that above described might in such cases prove insufficient to keep the water pure.

Such precautions will probably suffice to preserve the water free from organic contamination in rural or thinly-populated districts. Any one who is in the habit of visiting country places will be aware how generally these precautions are neglected;—or ignored. Still, when stated, they will probably be accepted as reasonable, or self-evident.

All authorities are now agreed that the questions of drainage, ventilation, and water-supply, when properly understood, and acted upon, are the bases of sanitary reform. Such associations as the present, aided by the public press, are doing a good work in extending a knowledge of these subjects amongst the people; but much depends on individual effort in diffusing, as opportunity may offer, a knowledge of the principles of sanitary science.

The restricted limits necessarily assigned by the rules of the Congress to papers read before the sections, have obliged me to curtail my observations on the topic here dealt with. But my object will have been attained, if I have succeeded in calling the attention of those resident in country places to a source of disease which those who are acquainted with Irish villages and country residences must admit to be generally overlooked.

The accompanying table will show the succession of water-bearing formations (properly so called), which are absent, or but slightly represented, in Ireland, though largely distributed over England.

APPENDIX.

Water-bearing formations of England and Ireland.

[NOTE.—The term "Water-bearing" is here used to designate only those formations of a porous nature, through which water from the surface easily percolates, and settles in the form of an internal reservoir capable of being drawn upon by wells.]

ENGLAND. (*Water-bearing Beds.*)	IRELAND (*Water-bearing Beds.*)
Post-Tertiary Deposits, sand, gravel, and loam, &c.	Present.
Lower Tertiary, sand & gravel beds (Woolwich & Reading Bed.)	Absent.
Chalk-limestone.	Absent, except in the N.E.
Upper greensand.	Very slightly represented in the N.E.
Lower greensand.	Absent.
Purbeck and Portland Beds.	"
Coral rag and grit.	"

England—(*con*). (*Water-bearing Beds.*)	Ireland—(*con*). (*Water-bearing Beds.*)
Great oolite.	Absent.
Inferior oolite, &c.	"
Upper lias sands.	"
Marlstone or middle lias.	"
Lower Kemper sandstone (Waterstones.)	"
New red sandstone (Bunter.)	Present only in the N.E.
Permian sandstones.	Only traces.
Carboniferous sandstones and grit.	Present.
Devono-silurian or Dingle Beds (Lower old red sandstones.	"

Below the above are the older palæozoic or primary formations, which are not water-bearing in the sense here used, but give forth water from fissures by means of springs.

[*For discussion on this Paper see page* 389.]

On "The Rainfall of Ireland," by G. J. Symons, F.R.S.

Observations upon the amount of rain falling at isolated stations in the British Isles have been made for more than two centuries, the earliest records still existing being those for Townley, near Burnley, in Lancashire, which commence with 1677. In Ireland it was more than a century later before any observations were made, or at any rate before any were made of which I possess the records. The first Irish series known to me is that made by Dr. Kirwan, F.R.S., at Cavendish Row, Dublin, commencing in 1791 and continued to 1808. His gauge was on a roof 30 feet above the ground, a position which is now known to be very undesirable; but the quantity collected at that height—viz., 22 inches (on the average of 19 years) is fairly consistent with the amount which would probably have been collected in a similar position during recent years. The fall on the ground at Dublin is far larger; probably 30 inches is the true mean rainfall of the capital.

The habit of observing the fall of rain was slowly formed in Ireland; for, even half a century back, in 1834 there had been only six records commenced—viz. (in addition to Dr. Kirwan's):—

Linen Hall, Belfast.—Begun in 1796; stopped at the end of 1799; recommenced in 1812 and continued for many years.

Londonderry.—Begun in 1797, stopped in 1800.

Edgeworthstown.—Observations preserved only for 1798, 1807 and 1808.

Dublin.—Observations made by Mr. A. Semple in 1823 and 1824.

Markree, Sligo.—Observations commenced in 1833 and continued, with slight breaks, to the present time.

Even down to a quarter of a century back, when I began the collection and publication of rain records, the greatest number of stations which had ever been simultaneously at work in Ireland was only 16, against 135 in Scotland and 327 in England.

In the autumn of 1863 I applied to the British Association for a grant with which to purchase rain-gauges for gratuitous distribution, and by letters in the Irish newspapers and by other means I was enabled to obtain a large number of offers of assistance, so that on January 1st, 1864, I had the satisfaction of knowing that the number of stations at work in Ireland was double what it had ever been before. I continued my efforts to increase the number of stations in Ireland, and in 1871 had raised it to 67, or four times what it was when I began. Still, however, it was far below what was needed for meteorological and *à fortiori* for engineering purposes. Therefore when the British Association met at Belfast in 1875, Section G. (Engineering) recommended a further grant for rain-gauges in Ireland, and by the cordial co-operation of the Irish press, and especially by the kind help of Mr. C. Eason (Messrs. W. H. Smith and Son), of Dublin, and somewhat vigorous action on my own part, no fewer than 66 new stations were established, and the entire number was raised to 153.

If observers never died, and if I could place them over the country like the pieces on a chess-board, 150 stations would probably suffice, but of course death is constantly thinning our ranks, and besides that, there is a tendency towards a plethora in the more active intellectual centres and the reverse in the wilder mountainous districts. I shall therefore be very thankful for offers of help, especially in the western counties.

From the above it will be obvious that even now the material for determining the rainfall of some parts of Ireland is absent; still it is far better than it ever was before, and having just completed some calculations upon the subject, I have thought that it might be of interest to show first, in the capital of the country, the latest and most accurate representation of the fall of rain over the whole of Ireland. At the same time it must be distinctly understood that when Irish Engineers imitate their English brethren and keep records of the fall of that rain with which they have to deal, when Irish gentry, Irish clergy, and Irish gardeners take to the habits of their friends both north and south of the Tweed, a far better map may be produced.

The broad general features are easily remembered, viz., that most places within about 60 Irish miles (77 English miles) of the south or west coast have upwards of 40 inches of rain per annum, and that central, east and north-east Ireland have between 30 and 40 inches, Dublin being almost, if not absolutely, the driest place in Ireland.

The above are the general features. Mountains always act as condensers, and therefore the rainfall in parts of Wicklow and amid the Mourne Mountains, in County Down, is as great as on the west coast. Hence, in Ireland, as in England and in Scotland, beautiful scenery and heavy rainfall are inseparably connected; but it would be a terrible mistake for any one to lose the charming scenery of Wicklow, of Rosstrevor, or of Newcastle because there might be a shower; and the citizens of Dublin may indeed be doubly grateful for the heavy rain on the Wicklow Hills; first, because it furnishes them at an exceptionally small cost with the ample and excellent Vartry water supply; and secondly, because the dryness of Dublin is slightly increased by the action of those hills on the clouds before they reach the city.

The land within 60 Irish miles of the south and west coast has generally a rainfall between 40 and 50 inches, but this is also increased in mountainous districts. It is only quite recently that, after many efforts, I have succeeded in getting any returns from Killarney, but those now obtained show that a considerable area of Kerry has upwards of 60 inches; and a record kept in 1883 in the Gap of Dunloe and forwarded to me by the Rev. G. R. Wynne, gives the large total of 104·30 inches. As the fall in that part of Ireland last year was some 15 per cent. above the average, this observation indicates that the mean fall in the Gap of Dunloe is about 90 inches.

There is one Irish record which is at present a puzzle to me. In 1874 I sent a perfectly accurate gauge to Kylemore Castle, Clifden, in the extreme west of Galway. The observer has been changed more than once, and recently a new gauge of a slightly different pattern has been sent to a new observer, yet all the records are consistent in giving an enormous rainfall—

about 80 or 90 inches. I have never been in the county myself, but I can see nothing in the position or configuration of the hills as shown on the maps which will explain so large a fall. I shall therefore be very glad if anyone will establish a second gauge in the neighbourhood, or in any way assist in explaining that which at present is rather an enigma.*

In conclusion, it may be well to mention why I urge so strongly that additional records of rainfall should be kept in Ireland. I do so chiefly on engineering grounds. The first thing that an engineer requires, is accurate knowledge of the quantities with which he has to deal, whether those quantities be wind force, weight of train, density of rock, length of span, or quantity of water. No gravitation water-works for a town can be economically laid out unless the engineer knows what quantity of rain usually falls on the gathering ground. No system of drainage will stand the test of years in which the maximum floods and the minimum dry weather flow have not been ascertained. So-called "accidents" to railway banks and culverts, and to town sewers, are generally traceable to imperfect knowledge, or insufficient consideration, of the amount and duration of rainfall.

Few things would please me more than to find an Irishman who would give the money, the patience, and the time requisite to work up the rainfall observations in Ireland: but until such a one is found, I will go steadily on relying upon the continued help of my present staff of 150 volunteer observers. Would that they were all here that I might thank them for their assistance!

[*For discussion on this Paper see p.* 389.]

On the Geology of the Neighbourhood of Dublin as affecting its Sanitary Conditions, by REV. M. H. CLOSE, M.A.

The city of Dublin is situated on the mouth of the River Liffey, at the head of Dublin Bay. The bay opens eastward; it is nearly seven miles in depth or recess, by nearly six miles

* [While attending this Congress I saw in a shop window a photograph of Kylemore Castle, and it shows that the ground rises very abruptly at the back of the castle, probably with sufficient abruptness to explain the large amounts hitherto recorded.—*Note added when the paper was read.*]

in width at its mouth. The city lies in a basin; it is all well within, that is below, the 100 foot contour line, or line of level, which passes close to Glasnevin, the Catholic Church at Phibsborough, the railway tunnel near the Zoological Gardens, Richmond Barracks, Harold's Cross, &c., running a long distance up the valley of the Liffey. The basin in which Dublin lies is pretty widely displayed; so that the town, as seen from the neighbouring hills on the south, does not appear to be in a confined hollow, though for the most part low lying. The tide runs up the Liffey to Chapelizod, so that it passes right through the town to its inland side; consequently the level of the middle parts of the town is but little above high tide. About seven miles south of Dublin we come to the northward end of the range of the Dublin, Wicklow, and Wexford mountains, which range extends to the S.S.W. as far as New Ross, or about seventy miles. On the north side of the mouth of Dublin Bay the Peninsula of Howth rises to the height of 563 feet, and on the south side of the mouth the Killiney Hills rise to 512 feet.

As to the geological structure of the neighbourhood of Dublin,—the city and its environs stand upon an outlet of the extensive limestone plain, which occupies most of the central parts of Ireland, and which reaches the coast only in a few places, as near Dublin. Regarding the so-called Old Red Sandstone of this district, of which there are some small exposures in different places, as the base of the Carboniferous formation; that formation was laid down on a floor of Lower Silurian, granite, and Cambrian rocks. These rocks emerge from beneath the Limestone on the south of Dublin, and there form the mountainous ground already mentioned. On the north of Dublin Bay the Cambrian rocks rise to form the Hill of Howth; while the Lower Silurian emerges at Lambay Island and at Portrane, on the opposite coast, and about Balbriggan, at the northern end of the County Dublin. The Carboniferous Limestone thus lies in a trough or depression in the older rocks, in which it was deposited unconformably, as its upper parts overlap the lower, both on the north and on the south, and there lie directly on the older rocks. This formation, then, around and above the head of Dublin Bay does not form a stratigraphical trough; though in the northward neighbourhood of Dublin it might be said to constitute one side of such. Dublin and its environs stand on the middle and upper divisions of the Carboniferous Limestone, which about here are not distinguishable, and are composed principally of Calp, or a dark earthy limestone with dark grey shales, though occasionally containing beds of good pale limestone fit for burning; its thickness in this district is unknown. The Lower Limestone, composed generally of a much purer and often very pure limestone, crops out to the northward of Dublin.

The superficial quaternary formations consist, first and principally, of stiff boulder-clay containing well blunted and scratched blocks and stones. As shown by its materials and the circumstances of its occurrence, it has been carried hither from the westward, or, as the groovings and scorings on the rocks produced by the passage of its stones indicate more accurately, from the W.N.W. Thus, Lower Silurian and granite subsoil on the south of Dublin is covered by limestone drift, and has a limestone soil and water strongly impregnated with lime. In the higher parts of Dublin it is this formation which forms the surface. The boulder-clay is in many parts of the district covered with water-washed sands and gravels, and with mounds and ridges of such material, called eskers. A portion of the western side of Dublin stands on this deposit. The low ground of the eastern and of the central parts of the city along the Liffey consists of raised beach; this extends from beyond the mouth of the Tolka River on the north, to Donnybrook and Merrion on the south, penetrating up the course of the Liffey and merging into its alluvium. Some of the low ground about the mouth of the Liffey has been artificially formed from the dredgings of the river.

In considering the sanitary relations of the geological conditions, thus briefly described, we shall pass by the older and deeper formations, with which we are but little concerned at present, and begin with that pre-quaternary formation on which the city directly rests. This, as we have seen, is Calp, or earthy limestones and shales of some considerable depth, which is underlaid by pure Lower Limestone, which comes to the surface northward of Dublin. The Calp, regarded lithologically—that is, with respect to its material—is not a good water-bearing formation, on account of its impermeability. This is illustrated by the fact, that wells have been sunk in Dublin to very considerable depths, and at great expense, without meeting with water. If the borings had reached the water-bearing strata of the Lower or pure limestone, beneath the Calp, doubtless water would have been obtained, since, as we have said, this reaches the surface northward of Dublin.

But though the undisturbed Calp is generally an impermeable and bad water-storing and water-yielding formation, yet its occasional interstratified beds of pure limestone and sufficient breaks and faults may, in places, allow the ground-water to pass freely enough; and, consequently, there are numerous springs and wells within the area of Dublin, both north and south of the Liffey, though far from enough to afford a water supply sufficient for the citizens generally.

As the population increased it became necessary to obtain water from other sources, and recourse was had to the Royal Canal, the Grand Canal and the river Dodder. But besides the want of sufficient head of water to afford the requisite hydraulic pressure to force the water to the higher parts of the town, all these sources of water, as well as many of the wells, were seriously contaminated by organic and other impurities.

In consequence of this the project was set on foot of obtaining water from the Vartry valley, Co. Wicklow, with what success we all know. The copiousness of the supply obtained has far exceeded the expectations even of the promoters of the scheme. Thus the upper part of the catchment basin of the Vartry river has artificially become part of the Dublin basin, in the geology of which we are now interested from the sanitary point of view. It lies away from, and above, the limestone drift, which so greatly affects water even on other than limestone areas, and is all situated on the Cambrian and Lower Silurian rock formations, both of which afford pure spring water, which of course is affected somewhat by the humus or vegetable soil, of comparatively little account in that district. The result is a very pure soft water, pleasant to drink and admirably adapted for all household purposes, and thus conducive to health, comfort, and economy in various ways. It is principally to the great activity and zeal of the late Sir John Gray, Chairman of the Water-works Committee of the Corporation, that the citizens of Dublin are indebted for this great benefit.

The Vartry water is, of course, capable of becoming very impure if the house-tanks from which it is drawn be not properly attended to; this, of course, is not to be laid to the account of the water itself. We may here mention, though it is beside our present subject, and a comparatively unimportant matter, that the water from the other sources was so charged with lime salts that it gave rise to troublesome incrustations of lime in boilers, &c. The Vartry water has a great advantage in this respect, but there must be placed on the other side of the account that its very purity enables it to attack and oxidate the insides of iron pipes, boilers, &c., to an inconvenient extent.

With respect to the condition of the soil about Dublin—over the greater part of the neighbourhood, and in the higher parts of the city, it rests directly on the stiff, impervious boulder clay; and in the low parts on the east, and along the Liffey, on the raised beach already mentioned, which consists of porous sands and gravels. The imperviousness of the boulder-clay, which prevents the surface-water from descending is, of course, calculated to maintain dampness in the soil lying upon it. This tends to produce the evils well known to be due to such a circumstance. Of course, the sanitary condition of a district is the complex product of a great variety of factors, and when considering these separately we can speak only of the tendency of each. A soil kept moist by an impenetrable subsoil is colder than it otherwise would be, and produces humidity of the air, thereby tending to cause rheumatism, colds, and affections of the respiratory organs. In some cases the moisture of the soil must promote noxious exhalations, which have their own results in fevers, &c.

Passing over a limited area in the west of Dublin, which seems to be covered by esker material, we shall now consider the low gravels, &c., of the raised beach in the eastern part of the city, which penetrates into the central parts, and, higher up, merges into the alluvium along the sides of the Liffey. Dr. Mapother, in his *Lectures on Public Health*, 2d. ed., 1867, shows close correspondence between prevalence of cholera and lines of water courses in the area of Dublin; though, as he points out, this may be partly due to some of the streams having been converted into sewers, which may not sufficiently carry off the land drainage, or which, from defective construction, may allow their contents to pass into the surrounding soil.

Dr. Grimshaw has made some elaborate investigations, in continuation of Dr. Mapother's observations, to test the truth of some of Pettenkofer's views respecting the insalubrity of porous ground *in a city*, or thickly-populated district. He gives detailed results of his researches in a paper in the *Dublin Journal of Medical Science*, April, 1878. He shows that, in corroboration of Pettenkofer's conclusions, there was a great proportional preponderance of cholera cases, both on the pervious formation of the raised beach and close to old stream courses. He observes that a careful consideration of the conditions produced by one of the old stream courses shows that they are very similar to those produced by the presence of a pervious stratum, such as the gravel beds of Dublin. The old stream course, contaminated by sewage, with houses built in it and alongside it, with porous foundations, and possibly standing on the débris of old houses, may have much the same effect, relatively to the present matter, as a gravel bed. The porous ground, of whatever kind, absorbs and retains sewage matter; whilst on impervious ground, like that composed of boulder clay, this is better enabled to flow away and to be carried off by surface water. As Pettenkofer shows, porous, contaminated ground is most dangerous, *cæteris paribus*, when the surface of the ground water is rising and driving upwards the gases contained in the interstices of its materials. Pettenkofer considers that the discovery, by Koch, of the cholera bacillus does not necessitate any modification of his views on the matter in question.

Within the area of Dublin the porous ground is damp, from being in a low situation to which the surface-water gravitates; while the soil on the impervious boulder clay is damp for the reason mentioned above. The character and conditions of the Calp limestone tend to increase the dampness of the soil generally; because while lithologically impervious, it must be, as we have seen, traversed by many breaks or faults which let up the ground-water from beneath which has come from higher parts of the surrounding neighbourhood; while such divisions would not be calculated to drain a stiff clay as well as general permeability to water would do. This suggests the mention of a disadvantage connected with the Vartry water-supply which results from its very excellence, convenience, and copiousness. The great employment and great, perhaps unpreventible, waste of it add to the surface water, which is not sufficiently carried off from the lower ground by drainage. In addition to which, the great disuse of the wells must cause a rise of the surface of the ground-water, both beneath the boulder clay and in the low-lying gravels. This is illustrated by the fact that within the precincts of Trinity College the level of the ground-water had risen to such an extent that it was found necessary to keep it down by pumping, at the expense of about £1 per day. This demonstrates the necessity of some such scheme as that proposed, of making intercepting drains or sewers along each side of the Liffey, whence the water and sewage should be pumped.

With respect to the general form of the ground in the vicinity of Dublin, which is connected with and dependent upon its geology, there cannot be much doubt but that the Dublin mountains must have some beneficial effect in occasionally supplying the city with mountain air; and this, apparently, without increasing the annual rainfall, which, as a general rule, is less here than anywhere else in Ireland, according to Mr. Symons' tables. To this may be added that the prevailing direction of the wind in Dublin, which is W., and not S.W., the prevailing direction for the country at large, seems to be principally due to the lower strata of the south-westerly winds turning at Dublin into the wake of the Dublin and Wicklow range.*

* Vessels leaving Dublin or Kingstown with a westerly wind intending to go down Channel very frequently find the wind against them,—that is, with much southing,—when they have got off Bray Head; this difference being clearly the effect of the mountains.

With the exception of the easterly wind, the westerly wind along the valley of the Liffey is that best calculated to *scour* the basin of Dublin of mists and exhalations, and this is the prevailing wind, thanks, in great part, to the mountains.

As shown by statistics, the prevailing westerly draught of good air along the Liffey more than makes up to the dwellers on the quays for the deleterious effect of the effluvia from the bed of the river at low tide. It appears that this effect is felt much more strongly in the streets which run north and south from the river than upon the quays.

Easterly winds will clear the basin of Dublin still better, but they are obviously undesirable in other ways. It has been pointed out that the *aspect* of the bay and the hills on each side of its mouth must act disadvantageously by causing an increased draught of such winds over Dublin.

The general tendency then of the geological conditions of the neighbourhood of Dublin to produce dampness and coldness of soil and of atmosphere must be modified, to an appreciable extent, by the circumstances now mentioned.

The grand lesson that is taught by the consideration of the geological conditions of the neighbourhood of Dublin is the necessity of improved drainage of the subsoil on which the city stands.

This discussion applies to the four preceding Papers by Dr. C. A. Cameron, Prof. Hull, Mr. G. J. Symons, and the Rev. M. H. Close.

Dr. Tichborne (Dublin) could bear testimony to the rise in the level of the water in wells in many places since Dublin was supplied from Vartry. In one particular case, although the level of the water was higher its quality was not changed, as evidenced on comparing an analysis lately done, with an old analytical report made previous to the introduction of the Vartry supply.

Dr. Edgar Flinn (Kingstown) suggested that where wells from 12 to 18ft. deep were used they should be covered in and cemented all round six feet from the surface; and that only one bucket or utensil should be allowed to be used for drawing the water from each well: thus a fruitful source of contamination would be prevented. A great proportion of the epidemics of infectious diseases that occasionally decimated large districts were distinctly traceable to the contamination of drinking water with sewage or other animal matter. Hence it was evident that where the people drew their water supply from wells great care should be taken to prevent the least possible amount of pollution.

Surgeon-General De Renzy (Bray) could not concur in Pettenkofer's views with regard to geological formation and cholera; the result of his own observations, extending from the Punjaub, one of the driest countries in the world, to Assam, one of the wettest, being that the disease had no dependence whatever on geological formation. He had known cholera to prevail at every elevation, from the level of the sea to heights of upwards of 7000ft. in the Himalayas, on every description of soil, in places where the subsoil water was within three or four feet of the surface, as also in places where the soil was utterly destitute of moisture to a depth of 100ft, or more. At Peshawar, a place notorious for its cholera epidemics, the soil is absolutely dry to a depth of over a hundred feet. The trees would all die from want of moisture if they were not supplied with water by artificial irrigation, so dry is the subsoil. Sirsa is another place of the same kind. The soil is absolutely dry to a depth of 120ft.

Dr. W. J. Simpson (Aberdeen) considered that in view of the statements of Dr. Cameron the local authorities should certainly take up the subject of the water supply. He did not think Ireland was exceptional in this respect, for knowing many parts of England and Scotland very well he could say that in the rural districts especially, and in many of the towns, the water supply was difficient in purity.

Prof. Hull (Dublin) remarked that the more one heard these discussions the more one became impressed with the enormous value this Association must be to any district in enforcing a knowledge of sanitary measures, particularly in regard to water supply and drainage. Everyone who had had much experience must know the profound ignorance that prevailed in many rural districts on this subject. As to Dublin it was a reproach upon it that, with this Congress sitting there, they had no complete system of main drainage in operation, and he hoped that if ever the Congress returned this reproach would have been wiped away. As to the question of the rise of underground waters it was desirable they should have further information supplied to them from year to year, and this could only be obtained through the officers of the Corporation. He begged to move that after the statements which have been made with reference to the rising of the ground waters under the terrace bordering the sea and the Liffey, the Council of the Sanitary Institute be recommended to request the Corporation of Dublin to consider the desirability of making arrangements for determining the rise and fall of such waters.

The motion was seconded by the Rev. M. H. Close, and carried unanimously.

On "*Air and Ventilation*," *by* John Collins, F.C.S., F.G.S.

"The strength of a people does not depend on the absolute number of its population, but on the relative number of those who are of the age and have the strength for labour."

Under the ordinary conditions of our lives there are ordinary causes of disease always present among us, around us, and often within us, which, seeking a weak point in our armour, can be withstood only so long as we maintain a resistance more powerful than the attack.

It is the young, the aged, the intemperate, or those exhausted by toil or mental effort, who give way.

Disease begins where resistance ends, and resistance is always impotent where vital force is weakened or destroyed.

Sanitation aims to increase that power of resistance.

It affects the comparatively strong, making him stronger, while it lessens the weakness of the already weak. It assists in the provision of better dwellings, of more efficient drainage, of provision for copious supplies of fresh air, and of pure water. It leaves a mark on a community which is as legible as a brand on the forehead of its people. Their nobler forms, brighter and more cheerful faces, their clear complexions and more elastic gait are unfailing tokens of improved sanitation.

At home or abroad, the condition and arrangement of houses and streets, and the physique and beauty of the people, indicate most surely the attention which is paid to the laws of health; and the "death-rate" and the sick-roll will vary as the attention which has been paid to sanitary requirements.

Our objects should not be very far in advance of the convictions of those with whom we have to deal. "Can a man not do what he likes with his own?" "An Englishman's house is his castle!" These are "saws" so familiar that we have come almost to admit them as truisms. And it is hence the more difficult to impress this fact, that the most precious possession of a man—viz., his life—is not his own to do with it whatever may seem best in his eyes. It is the property of the state, for every man who is a member of a community is a unit making up its strength, or its weakness, and he belongs to it.

Our existing sanitary laws arm us with powers to close polluted wells and pumps, prohibit the tenancy of dwellings unfit for human habitation, and prevent undue crowding therein, to inspect common lodging houses, and prohibit the doing or the leaving undone any act which, resulting in a nuisance, tends to injure public health.

But the great secret of any real improvement in our sanitary condition is the provision for the supply and circulation of purer air in our dwellings and workshops. A plentiful supply of good wholesome water is one of the Creator's best gifts, and is an absolute necessary of life. It cannot be altogether neglected without entailing misery, disease, and death. By drinking foul water we may, and we undoubtedly do, often incite disease; but this is insignificant when compared with the results arising from the steady imbibition of impure air. For we do not drink air as we do water—intermittently—and to a comparatively small extent. We imbibe it equally during our sleeping as in our wakeful hours, and the *smallest* interference with the regularity of this supply is fatal.

The atmosphere is, speaking generally, one mass of impurities.

Every person, on an average, pours into the air about ½lb. of used up carbon per day. This comes from the lungs mainly into the air as carbon dioxide, which is not capable of supporting animal life. Hence, in a town population of 100,000, we have a daily addition to the already impure air of 81 tons, 16 cwts., 3 qrs., 17 lbs. of an irrespirable gas from this source. Then we have "smoke," together with the many and varied products of combustion and of chemical industry.

Much of the evil which would result is, fortunately for us, avoided by the working of the beneficent natural law of "gaseous diffusion" which is alway at work.

It should never be forgotten that it is stagnant air which is dangerous. It is more what we abstract than what we add which gives to the air its poisonous characteristics, and this is in a lesser degree what happens to everyone who is poisoned when deprived of the constant changes of respired air by adequate ventilation. We create a poison to our system when the atmosphere we breathe is not surely and constantly renewed. We slowly and surely undermine the vital force and power within us, and, when infection approaches, we are found unable to resist the attack.

Our town population of 100,000 would probably occupy not less than 20,000 houses, each of which will burn at least 1 cwt. of coal per week. Hence we get a domestic consumption of 1,000 tons weekly. Taking the mean average sulphur in this coal as 1·25 per cent. as oxydized, we shall get 12·5 tons of sulphur equal to 37·5 tons of sulphuric acid. And the money value of this noxious and hurtful gas with which we pollute the air, and which is lost to us, taken at £5 per ton, is £67 10s., or

£3,250 per annum. What must be the magnitude of the evil; what the loss, when it is remembered that we raise over 115 millions tons of coals yearly. This is an addition to the atmosphere, and outside our dwellings.

But what do we find inside?

In every room where we find artificial lighting we have a concurrent production of foul air, for the removal of which efficient ventilation is required. If we take a room in which four ordinary gas jets are burning, each consuming its five cubic feet per hour, we have a total consumption of 20 cubic feet per hour, and of 100 cubic feet in the five hours of a winter's evening. Taking a low percentage of sulphur compounds other than sulphuretted hydrogen, as present, viz., 14 grains sulphur for 100 cubic feet, we have 42 grains of sulphuric acid; and we have probably 12 grains ammonia, yielding 44 grains of nitric acid, in addition to 11 grains of water. Besides these, we have the products of combustion of the gas itself, viz., the carbonic dioxide and water.

It is said that eight million tons of coal are annually distilled for gas making. Allowing one ton for each 10,000 cubic feet of gas produced, we shall find we have some 80,000,000,000 cubic feet of gas produced and used per annum. And if we assume that all this gas when supplied to the consumer contains the afore-mentioned quantities of sulphur and ammonia, we may see how almost incredible is the waste and damage. To take a case of a town known to the writer, where the make is over 400,000,000 cubic feet per annum, we shall have this waste and damage represented by some 4·5 tons sulphur, equal to 13·5 tons sulphuric acid, together with about four tons of ammonia. This four tons of ammonia represents about 16 tons of gray sulphate, containing 24 per cent. ammonia, and worth about £290. So that while we are content to bear the presence in such quantity of noxious and non-illuminant gases, causing damage and loss in every way, we are also, and absolutely, throwing away the £290 per annum before mentioned.

Coal smoke is a luxury, inasmuch as we are content to pay very handsomely for it. It is not a very substantial thing, and yet see how it leaves its mark on our public buildings—on our walls, inside and out our dwellings, and in our lungs. Some 500 years ago our Parliament busied itself with this "burning" question. It complained of the smoke and noxious vapours arising from the use of "sea kole," and proclamations were vainly made against its use.

The hideous blackness which robes us in mourning, and which gives an unartistic Rembrandt-like tint to the surfaces of our public buildings—which defiles our dwellings and all our surroundings—must be removed, if not on æsthetic considerations, on appeal to the pocket. We are all more or less affected by the question, and its gravity to the teeming thousands of our large manufacturing centres cannot be over estimated.

The atmosphere of the dwelling necessarily partakes of the character of that outside, and by that amount adds to the air pollution of small, ill-ventilated, over-crowded, and unsanitary dwellings.

A room 10 feet square has a capacity of 1,000 cubic feet, and this is no more than is necessary for one adult person, and doubly necessary in the case of a bed-room.

Respiration and occupation have a certain and easily estimated vitiating effect on the atmosphere, and, for sanitary uses, it should be entirely changed by ventilation twice or thrice every hour. That is to say 2,000 or even 3,000 cubic feet of air, pure and fresh, should be thrown into the room for each person occupying it during each hour. This is no fanciful, extravagant, or excessive estimate, but it is founded on the results of close observation, and of careful analysis. One test of the quality of the air after respiration is furnished by the quantity of carbonic acid gas it is found to contain, as this compound is not only injurious in itself, but also affords a very practical means of estimating other impurities such as organic matters. Pure air contains, in every 1,000 parts, oxygen, 209·6; nitrogen, 790·0; carbonic acid, 0·4, with minute traces of ammonia and organic matter, and a little (variable) quantity of moisture.

Air, to be regarded as pure, should not contain more than 0·4 parts carbonic acid per 1,000 of air, and it has been very frequently observed that when this quantity increases to 0·6 per 1,000 our sense of smell indicates that the air of the room is perceptibly tainted. It is obvious that these conditions are by no means fulfilled in the case of the majority of mankind. In the dwellings of the labouring poor they are scarcely ever so, and in the houses of the rich rarely so. No doubt we do sometimes find them fulfilled in bed-rooms, but hardly ever in sitting and in "living" rooms.

It would be interesting to enquire fully into the various modes in which the air is polluted and deteriorated, but the limits of this paper will not admit of this; and it may suffice to say it is by combustion and respiration—by sewage emanations and from excrementitious matters, and by noxious vapours from various trade processes.

But we may roundly assert that air, even after respiration, is changed in the following characters:—Its carbonic acid is increased from 0·4 to 0·5 per cent., while its oxygen is reduced

by about 8 per cent. Besides, some effete organic matter is thrown off by the lungs, and a fine epithelial dust from the body. Wherever we have this organic matter, and especially when it is combined with water, we must assuredly have putrefactive decomposition, which, in its turn, gives rise to various volatile compounds which induce a lessened power of resistance to the effects of disease. Who has not remarked the sickening, fœtid, unwholesome smells from low types of the "great unwashed," and from his even still more neglected dwelling: and who that has realised this smell has not been affected thereby?

I append tabulated results of analyses of air under varied circumstances, which, read with and by the light of this paper, may be found instructive and of some value.

They are in part my own work, and for the remainder I am indebted to my assistant, Mr. Walter Hepworth-Collins, who has given long and interested attention to the subject.

Tabulated Results.—Air Analyses.

Samples taken.	Grains per cubic foot. Ammonia. Free.	Albumenised.	Hydrochloric Acid.	Sulphuric Acid.	% vol. Carbon Dioxide.	Remarks.
1. In Garden at Farnworth	36·1	85·5	102·2	99·6	0·046	Average 800 obs.
2. In Little Lever	25·9	49·4	116·5	102·4	....	750 "
3. In centre of Farnworth	38·6	92·0	87·9	123·3	....	800 "
4. Near large works, Bolton	16·7	4·3	36·4	194·3	....	800 "
5. In narrow back Street, Bolton ..	29·9	53·6	36·9	169·2	....	800 "
6. New Public Park, Bolton	5·8	26·8	25·2	45·2	....	750 "
7. National School, "Howarth's" ventilated	....	....	....	....	0·0461	....
8. Quarter Sessions' Town Hall, Bolton ..	....	....	....	....	0·0464	....
9. Bed-room, 18in. from floor ..	....	....	....	....	0·0614	....
10. " 18in. from ceiling ..	....	....	....	....	0·0501	....
11. " 18in. from floor ..	....	....	....	....	0·0465	....
12. " 18in. from ceiling ..	....	....	....	....	0·0624	....
13. Public Hall, Southport, unventilated ..	....	....	....	....	0·0602	....
14. " " { "Howarth's" ventilated }	....	....	....	....	0·0462	....

"EDUCATION BY PROVERB IN SANITARY WORK,"

LECTURE TO THE CONGRESS,

BY

Alfred Carpenter, M.D., M.R.C.P. (Lon.), C.S.S. (Camb.).

There are two points in the study of the causes which shorten human life, which must strike all thinkers upon the subjects of health, of disease, and of death. These points may well form the commencement of my address to the earnest sanitarians who are now assembled in this city of Dublin.

The first of these points is the sacred feeling which attaches to human life, to the spiritual essence by which we live and move, and have active existence, and which feeling is instinctive in the breasts of all who may be assumed to have had the privilege of a spiritual contact with the Supreme Being; this spiritual essence being a something altogether different to that life which belongs to animated nature, exclusive of that attached to humanity.

The second is the carelessness with regard to this same life, the indifference with which its extinction is regarded by barbarians and uncivilised communities, and also by a portion of the civilised world, who ignore the existence of a Supreme and Benevolent Architect of the Universe. The more uncivilised the race, the less is the respect which is paid to the maintenance of human life. There are still nations upon the face of the globe, who, when their parents or relations become old or labour under any distemper which cannot be cured; cut short their days with a violent hand, in order to be relieved from the burden of supporting and tending them: and there are yet some countries in which the children are destroyed when