# AIDS TO SANITARY SCIENCE

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# AIDS

TO

# SANITARY SCIENCE,

FOR

*THE USE OF CANDIDATES FOR PUBLIC HEALTH QUALIFICATIONS.*

BY

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statistics and mathematical calculations generally ; with a view, therefore, of making these more easily understood, I have added examples of questions (taken from examination papers), so as to exhibit the methods by which they may be solved.

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# AIDS TO SANITARY SCIENCE.

## CHAPTER I.

### INTRODUCTORY.

It is to the University of Dublin (Trinity College) that the honour belongs of first instituting, in 1871, a special examination in public health subjects. Since then the various other Medical Licensing Bodies (with the exception of St. Andrews University, the Apothecaries' Company, London, and the Apothecaries' Hall, Dublin) have followed in its footsteps.

In 1886 a number of gentlemen holding those qualifications associated themselves together as The Public Health Medical Society, and were successful in influencing Parliament to insert a clause in the Medical Act of that year, giving the General Medical Council the power to register diplomas granted after special examination for proficiency in Sanitary Science, Public Health or State Medicine, provided that the Council was satisfied that the diplomas had been granted under such conditions of education and examination as to ensure (in the judgment of the Council) the possession of a distinctively high proficiency, scientific and practical, in all the branches of study which concern the public health; and the Council, in forming its judgment, have determined to be guided by the following rules :

(1) A period of not less than twelve months shall elapse between the attainment of a first registrable qualification in Medicine, Surgery, and Midwifery, and the examination for a diploma in Sanitary Science, Public Health or State Medicine.

(2) Every candidate shall have produced evidence of having attended, after obtaining a registrable qualification, during a period of six months, practical instruction in a laboratory approved of by the body granting the qualification.

(3) Every candidate shall have produced evidence of having for six months practically studied the duties of outdoor sanitary work under the Medical Officer of Health of a county or large urban district.

(4) The examination shall have been conducted by examiners specially qualified, and shall comprise laboratory work as well as written and oral examination.

(5) The rules (1, 2, and 3) as to study shall not apply to

(*a*) Medical practitioners registered on or before January 1, 1890.

(*b*) Registered medical practitioners who have for a period of three years held the position of Medical Officer of Health to any county, or to any urban district of more than 20,000 inhabitants, or to any entire rural sanitary district.

As it is uncertain whether a sufficient number of such Medical Officers of Health are willing to undertake the duty of instructing candidates, it is not intended for the present to insist upon Rule 3.

Up to 1888 no special qualification had been required of medical men desirous of becoming Medical Officers of Health, but in that year an important step was taken by Parliament by the provision in the Local Government Act, that, except where the Local Government Board, for reasons brought to their notice, may see fit in particular cases specially to allow, no person hereafter shall be appointed the Medical Officer of Health of any county or county district or combination of county districts, or the deputy of any such officer, unless he is legally qualified for the practice of medicine, surgery, and midwifery.

No person shall after the first day of January, 1892, be appointed the Medical Officer of Health of any county, or of any such district or combination of districts, as contained according to the last published census for the time being a population of 50,000 or more inhabitants, unless he is qualified as above mentioned, and also is registered in the Medical Register as the holder of a diploma in Sanitary Science, Public Health, or State

Medicine, under section 21 of the Medical Act, 1886, or has been, during three consecutive years preceding the year 1892, a medical officer of a district, or combination of districts, with a population according to the last published census of not less than 20,000, or has before the passing of this Act been for not less than three years a medical officer or inspector of the Local Government Board.

A similar provision has been incorporated in the Local Government (Scotland) Act, 1889.

*Examinations.*—The following information in regard to the examinations of the various bodies has been compiled from the most recent prospectuses, and may be of use to gentlemen desirous of acquiring a qualification in Public Health. Most of the examining bodies throw open their examination to any person whose name is on the Medical Register, but certain of them, viz., the Universities of London, Oxford, Glasgow, Aberdeen, and the Royal of Ireland, admit only their own graduates, while Edinburgh University allows graduates of any British or recognised Foreign or Colonial University to enter for its B.Sc. (Public Health), provided that the two courses of lectures are taken at Edinburgh University and the laboratory work at a recognised laboratory ; the University of Durham is open to anyone, but the candidate must attend certain courses at the Newcastle School of Medicine, and at the Fever Hospital. This University also has a modified examination for Medical Officers of Health of three years' standing, under 30 years of age. The University of Dublin opens its examinations to graduates of Oxford and Cambridge as well as to its own.

*Age.*—Most of the bodies allow candidates to enter for the examinations at the earliest possible date after registering the ordinary qualification, that is at 22 ; but the University of Cambridge and the Royal Colleges of Physicians and Surgeons of England require that candidates be at least 23 years of age on entering for Part I., and at least 24 for Part II. of the examination.

*Subjects.*—Some divide their examination into two parts, but in all, the subjects in which candidates are required to show proficiency are very similar.

Part I. usually comprises Physics and Chemistry ; the principles of chemistry, and methods of analysis, with especial reference to analyses of air and water ; application of the microscope ; the laws of heat and the principles of pneumatics, hydrostatics, and hydraulics, with especial reference to ventilation, water supply, drainage; construction of dwellings, disposal of sewage and refuse, and sanitary engineering in general; statistical methods. Candidates will be expected to understand the application of the general laws of chemistry to such cases as occur in the practice of an Officer of Health. It is not expected that Officers of Health will in general be able to act as public analysts, but that they will know the methods of analysis, and be able to interpret correctly the results of professional analysts.

Part II. comprises laws of the realm relating to public health; origin, propagation, pathology, and prevention of epidemic and infectious diseases; effects of over-crowding, vitiated air, impure water, and bad or insufficient food; unhealthy occupations and the diseases to which they give rise; water supply and drainage in reference to health; distribution of diseases within the United Kingdom, and effects of soil, season and climate.

Examinations are made by written papers, orally and practically.

In addition to the subjects named above, mental physiology is required at London University; practical knowledge of infectious diseases at Durham; geology at the Royal University of Ireland.

At the University of Edinburgh very complete knowledge is required of analytical chemistry in all its branches, in natural philosophy, in elementary astronomy, in mensuration and drawing, and in the interpretation of plans, drawings, etc.

The Faculty of Physicians and Surgeons of Glasgow expect candidates to be able to analyse water and milk quantitatively, and air for $CO_2$.

The King and Queen's College of Physicians and the Royal College of Surgeons of Ireland (combined), and the University of Dublin require more complete knowledge of general chemistry than most bodies; and also include medical jurisprudence; morbid anatomy, the method of conducting post-mortem examinations; and engineering, with the reading of plans, etc.

*Dates at which examinations are held.*—Some bodies examine only once a year; others oftener. The fees are variable. The particulars are as follows:

| | Fees. | Dates of Examinations. |
|---|---|---|
| The Royal College of Physicians, London, and Royal College of Surgeons, England | £5 5s. for each part ... | January (parts 1 and 2), July (parts 1 and 2). |
| University of Cambridge ... .. ... | £4 4s. for each part ... | October (parts 1 and 2). |
| University of Oxford... ... ... ... | £5 for the examination and £10 for the certificate ... | In the Michaelmas term. |
| University of Durham ... ... ... | £10 10s. for examination; £3 for licence to M.B. of Durham; £5 to others | April, September. |
| University of London ... ... ... | £10 under old regulations; £5 under new regulations | December. |
| University of Victoria ... ... ... | £4 4s. for each part ... | July. |
| Royal College of Physicians, Edinburgh ... | £5 5s. for each part ... | April. |
| Royal College of Surgeons, Edinburgh ... | £5 for each part ... ... | March and September. |
| Faculty of Physicians and Surgeons, Glasgow | £3 3s. for each part; £2 2s. for diploma ... ... | April, July, December. |
| University of Edinburgh ... ... ... | £5 5s. for each part ... | June. |
| University of Glasgow ... ... ... | £5 5s. ... ... ... | October. |
| University of Aberdeen ... ... ... | £3 3s. ... ... ... | March and July. |
| King and Queen's College of Physicians and Royal College o Surgeons, Ireland | £10 ... ... ... ... | February, May, and November. |
| University of Dublin ... ... ... ... | — | December. |
| Royal University of Ireland... ... ... | £2 ... ... ... ... | On notice being given. |

The subjects embraced in the two parts of the examination of necessity overlap one another to some extent, and it is therefore generally recommended that both parts of it be taken at the same time.

It is most desirable that gentlemen preparing for examinations in Sanitary Science should embrace every opportunity of gaining practical experience, and they should visit and inspect water-works, sewage farms and other methods of sewage disposal, hospitals, gas-works, factories, etc., etc. At the Parkes Museum of Hygiene in London, and other sanitary exhibitions, many appliances may be seen in working order.

As a guide to what should be read, the lists of books which are issued by the various examining bodies may be consulted. It is well also to procure copies of the papers set at previous examinations.

The Sanitary Institute holds examinations from time to time, and grants certificates of competency in sanitary knowledge. The examinations are arranged in two grades, and are intended to enable local surveyors and inspectors of nuisances, or persons desirous of becoming such, or of obtaining the certificate of the Institute, to prove their competency in the subjects of examination. Candidates must be 21 years of age : the fees are £5 5s. for the higher, £2 2s. for the lower grade.

## CHAPTER II.

### WATER SUPPLY.

THE subject of the supply of water to towns may be considered under the three headings of :

(1) Quantity of water supplied per head.
(2) Mode of collection, storage and distribution.
(3) Composition, at source and throughout the district supplied ; and the possibility of contamination at any point.

*Quantity.*—The amount actually supplied in this country varies from 5 gallons per head per day to 140 gallons (at Middlesborough); London averages 28·3 gallons, Glasgow 50 gallons, New York 83 gallons.

It varies according to wants of the locality. If water must be limited, 4 gallons for each adult per day is the least amount allowable. For personal and domestic use, 12 gallons per head is the usual minimum; with baths, water-closets and waste, 25 gallons, and this is the quantity that experience shows to be necessary for keeping the sewers in proper working order.

The following table gives the quantities required on an average for various purposes :

| | Gallons per head daily. |
|---|---|
| *Domestic use :* | |
| Drinking (besides which 30 to 50 ounces is taken in bread, meat, etc.) ... ... | 0·33 |
| Cooking ... ... ... ... ... | 0·75 |
| Ablution, including sponge-bath, 2½ galls. | 5·00 |
| Share of utensil and house washing ... | 3·00 |
| Share of clothes washing ... ... ... | 3·00 |
| Water-closets ... ... ... ... | 6·00 |
| General bath (weekly about 30 gallons)... | 4·00 |
| Unavoidable waste... ... ... ... | 3·00 |
| | 25·08 |
| *Town and trade purposes :* | |
| Washing streets, courts, etc., extinguishing fires, supplying fountains, etc., allowance for trade and for animals in non-manufacturing towns (varies; London has 18 gallons) ... ... ... | 5·00 |
| Allowance for exceptional manufactures | 5·00 |
| | 10·00 |
| Making a total of | 35·08 |

In hot countries a large amount is required for bathing and washing.

*Sick* men require from 40 to 50 gallons, which is made up thus :

| | Gallons per head daily. |
|---|---|
| Drinking, cooking, washing of kitchen and utensils ... ... ... ... | 2 to 4 |
| Personal washing and general baths | 18 to 20 |
| Laundry washing ... .. ... | 5 to 6 |
| Washing hospital, utensils, etc. ... | 3 to 6 |
| Water-closets ... ... ... ... | 10 to 15 |
| | 38 to 51 |

London hospitals use from 20 to 99 gallons, while Glasgow averages 147 gallons. (Probably there is considerable unchecked waste at many hospitals.)

*Collection of water.*—The sources of supply may be classified under two main heads :

*Surface supply*, from brooks, rivers, lakes, surface-fed springs and shallow wells, etc.

Supply from *deep subterranean* sources, as from springs cropping out at the foot of mountain ranges, from natural reservoirs, from artesian and other deep wells.

*Rain water* is highly aërated, and when uncontaminated, is good and pleasant to drink ; but in this country, on account of atmospheric impurities, is seldom stored except for external use. The uncertainty of rainfall also tells against its use. It is found to contain 25 cubic centimètres of air in a litre, the oxygen being in larger proportion (32 per cent.) than in atmospheric air ; carbonic dioxide is $2\frac{1}{2}$ to 3 per cent. ; ammoniacal salts with nitrous and nitric acids are present in small amounts. In manufacturing towns rain is little better than a dilute solution of sulphuric acid, black from tarry matter and suspended soot. (Angus Smith has noted that sulphates increase as we pass inland and before large towns are reached, and could the sulphur from coal fires be excluded, would be the measure of 'the sewage' in the air.)

The rain also carries down chloride of sodium, calcium carbonate sulphate and phosphate, ferric oxide, organic matter, *débris* from dust, and plants of the lowest orders. When it is desired to collect rain water from the roofs of houses, automatic separators are employed to prevent the first portion of the rainfall passing to the storage-tank. They cant and throw off the first lot of water which has washed the dirt from the roof.

*The average annual rainfall* in England is 30 inches, and varies from 22 to 140 inches. A quantity is lost by evaporation or by sinking into ground. This varies from one-half to seven-eighths, according to the season of the year and the porosity of the soil.

The amount of water given by rain is calculated from (1) amount of rainfall, and (2) the area of the receiving surface.

The former is ascertained by a rain gauge ; the area must be measured (4,840 square yards=one square acre ;

640 square acres = one square mile); then area in square feet × 144 (to bring to square inches), × rainfall = total amount (in cubic inches) on area in given time.

Product (in cubic inches) ÷ 277·274, or × 0·003607 = number of gallons.

One inch of rain = 4·673 gallons on every square yard, equal to 101 tons of weight on each square acre.

One cubic foot of water = 6·2355 gallons ($6\frac{1}{4}$).

One gallon of water weighs 10 lb.

Care should be taken that the numbers multiplied together are brought to the same denomination. In estimating the amount of rain that can be collected from a sloping roof, take the area as that of a transverse section of the house including walls and eaves; that is, take the area of the ground covered by the roof. If the average rainfall be 20 inches, it would only give 2 gallons per day to each person, if collected only from roofs of houses in towns, assuming each house to have an average roof area of 60 square feet to each individual.

In estimating *annual yield of water* from rainfall, or the yield at any one time, it is necessary to know: (1) the greatest; (2) the least; and (3) the average annual rainfall; (4) the period of the year when it falls; and (5) the length of the rainless season.

The greatest is generally about one-third more, and the least one-third less than the average. A safe basis is to take the average of the three driest years; this will generally be about five-sixths of the average annual rainfall. The rainfall varies in amount often in places near together.

*Ice* water is heavy and non-aërated; water in freezing loses part of its saline contents.

*Snow* often contains much organic matter, and should never be collected from the neighbourhood of dwellings to melt for use.

*Dew* is used sometimes in sterile regions and on board ship.

*River* water is rain derived directly from the atmosphere, and indirectly through part of the earth. The impurities vary according to part of country drained; the quality being worse after heavy rains.

*Spring* and *well* waters are influenced by the strata through which the water passes; thus it may be either good pure water, mineral water, or nothing more than diluted sewage.

*Wells* are divided into (1) *shallow*, less than 50 feet deep ; (2) *deep*, over 50 feet deep ; (3) *artesian*, derived from collections of water lying below an impermeable stratum which has to be perforated artificially.

In absence of definite information, the configuration of the country should be considered in regard to water supply. Springs at the foot of hills are permanent ; in flat districts the supply is doubtful, unless derived from a great depth ; in limestone regions springs from subterranean reservoirs are permanent ; in chalk districts springs are few unless below level of country generally ; similarly where sandstone obtains, but when there are deep wells large reservoirs must have been tapped. Water from granitic and trap formations is variable unless from lochs.

*To determine yield of springs, streams, etc.*—Water of a spring may be received into a large vessel of known capacity, and the rate of filling timed.

*To determine yield of a small watercourse.*—(1) Dam up course and convey water through a channel of known dimensions, as a wooden trough of certain length and in which depth of water is known and the time taken by a float in passing from one end to the other is measured.

(2) Or a sluice of known size is formed, and the difference of the water above and below is measured, discharge = area of opening of sluice $\times\ 5\sqrt{}$ head of water in feet.

(3) Or a weir is formed ; the waste-board having a thin edge and a free overfall.

(4) Or this plan which is sufficiently accurate may be adopted. A part of the stream is selected where it is free from eddies, and pretty uniform in breadth and depth for about 12 or 15 yards, or a part may be cut so. Drop in a chip of wood and note length of time it takes to float the given distance ; this will be the surface velocity, which is greater than the mean velocity ; then four-fifths of the surface velocity $\times$ area of cross section = yield of stream per second.

It should be determined at different times of the day and on several occasions.

The Rivers Pollution Commissioners in their sixth report give the following table as regards wholesomeness, palatability and general fitness for domestic use of waters from various sources:

| | | |
|---|---|---|
| Wholesome. | 1. Spring water. | Very palatable. |
| | 2. Deep well water. | |
| | 3. Upland surface water. | Moderately palatable. |
| Suspicious. | 4. Stored rain water. | |
| | 5. Surface water from cultivated land. | Palatable. |
| Dangerous. | 6. River water to which sewage gains access. | |
| | 7. Shallow well water. | |

According to *softness:*

1. Rain water (the softest).
2. Upland surface water.
3. Surface water from cultivated land.
4. Polluted river water.
5. Spring water.
6. Deep well water.
7. Shallow well water (the hardest).

The purest water comes from the granitic, millstone grit and hard oolite formations; also from the chalk, but it is hard; water from the selenitic with calcium sulphate is unwholesome; from alluvial it is very impure; and near the sea, wells are sometimes brackish.

**Storage of Water.**—To determine the amount of water which should be stored, it is necessary to know, when dependent on rainfall, (1) amount used and (2) ease of replenishing. This latter depends upon the rainfall and upon the area of catchment.

With a catchment area large in proportion to population, and with a fairly distributed rainfall, the necessary storage space will be less than in a district where there are long droughts to be provided for, and where, the catchment area being small, it is essential that loss by escape of water during heavy floods should be minimized by providing large reservoirs.

Average loss by overflow of storm water may be taken at about 10 per cent. of total fall; and the average proportion of rainfall available for storage at about six-tenths of the whole.

Reservoirs in rainy districts may contain 120 days' supply; in drier districts 200 days' supply.

Hawksley's formula for storage is $D = \frac{1000}{\sqrt{F}}$

D being number of days' supply to be stored, F mean annual rainfall (five-sixths of average). Storage capacity may vary from 25,000 to 50,000 cubic feet per acre of catchment area.

*To calculate size of reservoir.*—Number of gallons required daily for whole population ÷ by 6·23 to bring to cubic feet and × by number of days the supply is to last = size of reservoir in cubic feet.

All reservoirs require to be frequently cleaned; they should be covered in, and ventilated; in form, deep rather than extended, so as to lessen evaporation and secure coolness. If too large to be covered in, a smaller covered one with a filter between should be provided, containing three days' supply.

*Small reservoirs and cisterns*, such as are used in houses, are best constructed of slate set in good hydraulic cement; the overflow pipe should end above ground over a trapped grating. The supply for water-closets should be quite separate from that from which water is taken for cooking and drinking purposes. If the cistern is at top of house, there should be proper means of access for inspection and cleansing.

*Wells* should have a good stone coping to prevent entrance of surface washings during rain. To prevent subsoil soakings it is necessary to brick round the well for some distance down.

*Large reservoirs* are made watertight by a core of clay puddle; the inner slope is protected by a pitching of dressed stones, the outer by a covering of grass sods; the summit of the embankment should be 3 to 10 feet higher than the water level; the top is covered with broken stones; no trees or shrubs must grow on it; and care must be taken to prevent the possibility of rats burrowing into it; an overflow weir is provided to permit of discharge of flood-water from the drainage area, and is supplemented by a by-wash, which diverts the foul flood-water of the streams supplying the reservoir; there is a cleansing-pipe at the lowest level; the discharge-pipe bends upwards, and is perforated with holes at different heights, and has guards to prevent entrance of stones, wood, etc. Certain plants, as protococcus and chara, give off oxygen, and may be allowed in reservoirs; but duck-weed (lemna and pistia), and all dead vegetable matter should be removed.

**Distribution of Water.**—Two systems are in vogue for the distribution of water in towns; these are called the intermittent and the constant methods of supply.

(1) The *intermittent* necessitates storage in cisterns in the house for from one to three days, whereby the water becomes flat and insipid.

Disadvantages.—Risk of contamination in the cisterns from exposure to air from improper positions, as in water-closets; from improper construction and capacity.

An advantage is that the higher parts of a town do not run the risk of being deprived of water by the waste which takes place in the lower part.

(2) *Constant.*—Requires no storage,* except for water-closets and kitchen-boilers; and less water is wasted if fittings are good; there must be screw-down taps, and waste or warning-pipes placed so as to be readily seen. There should be a good screw stop-cock at entrance to each house; waste may be checked, and a more uniform supply given by the use of meters along the route. Water-waste preventing cisterns should be used for water-closets, the plan of putting the water-main in direct connection with the closet-pan or basin being most objectionable.

Disadvantages.—Insufficient supply leaves the pipes empty at times, and foul air is drawn in; if the pressure is small, a ferrule is put in the pipe, narrowing the diameter so that the water runs in a very small stream.

*Pipes.*—On both systems the water is conducted in

* The East London Waterworks Company have a section in the Act by which the company was constituted, that every person supplied with water on the constant supply system should, 'when required by the company, provide a proper cistern or other receptacle for the water with which he is so supplied.' This requirement of the company of a cistern from which water may be drawn for domestic purposes, irrespective of a cistern for water-closets, has been upheld by the Middlesex Sessions; and this company may refuse to supply water unless such cisterns are provided. This in great measure destroys the efficacy of the constant supply system.

large pipes of earthenware or iron, which may be either wrought, or cast, or galvanized, or lined with concrete, or covered with vitreous glaze (De Lavenant), or with Dr. Angus Smith's bituminous varnish.

Iron is best for the large pipes, and is necessary also for the small on the constant system on account of the pressure. With intermittent supply, pipes are made of iron, lead, tin, zinc, copper, earthenware, gutta percha, artificial stone, etc. Copper tinned and block tin pipes are good, but are eaten into if nitrates are present in the water.

Water should be laid on to every house, and to each floor in the houses of the poorer classes. An insufficient supply leads to deficient washing of persons, clothes, houses, yards, streets and drains, and produces a lowered state of health among the population.

*Size of pipes.*—The *greatest hourly* demand for water is about double the average hourly demand; hence main conduits must be correspondingly large

For calculating the size of pipes and delivery of water these formulæ are useful (Eytelwein):

D = Diameter of pipe in inches.
H = Head of water in feet.
L = Length of pipe in feet.
W = *Cubic feet* of water discharged per minute.

Then $W = 4{\cdot}71\sqrt{\frac{D^5 H}{L}}$ $\qquad D = 0{\cdot}538\sqrt[5]{\frac{L W^2}{H}}$

A simpler formula is given at p. 53, and may be used to ascertain the discharge from water supply-pipes.

*A head of water* is made up of a head of pressure and a head of elevation (Rankine).

(1) Head of pressure = the intensity of the pressure exerted by the particle expressed in feet of water.

(2) Head of elevation = the actual height of the particle above some fixed or datum level.

A foot of water at 52° ·3 F = 62·4 lbs. on a square foot (atmospheric pressure is not usually regarded).

**Admission of Impurities to Water.**—Impure water supply may be due to impurities of (1) mineral, (2) vegetable, or (3) animal nature, of which the last, especially when they are fæcal matter, are the worst.

They may gain admission to the water at the gather-ground, in transit, or during storage.

*In transit.*—Water in open conduits may be rendered impure by surface-washings, leaves, sewage, etc. The Rivers Pollution Commissioners divide such impurities into—

(*a*) *Sewage.*—All liquid and solid excreta, house and waste water; all impurities coming from dwellings. This is usually organic matter, and undergoes change into (1) ammonia, then into (2) nitrites, and finally to (3) nitrates.

(*b*) *Manufacturing.*—All manufacturing refuse, as from dye and bleach works, tanneries, paper-making, etc.

If conveyed in pipes, water may be contaminated by lead and other metals; by leakage from drains and sewers and gas-pipes; by impurities of the soil finding a way into pipes through some faulty joint.

*During storage.*—Wells and tanks are liable to have the water rendered impure by surface-washings, soakings, absorption of foul air by uncovered surface of water, leakage from pipes. A well drains an extent of ground like an inverted cone, the size of the area depending on the kind of soil; the radius of the cone = at least four times the depth of the well.

In India, clothes, even of cholera patients, are often washed in or near the tanks.

(1) *Mineral* matters in excess in water:

*Hard* waters produce dyspepsia, constipation, and sometimes diarrhœa; goitre and cretinism (are associated with magnesian limestone formation, but not everywhere, for magnesian limestone occurs in Scotland, Ireland and Scandinavia, without presence of these diseases; it has been suggested that when iron is in it, a different effect may be produced). Calculi and diseases of bones are alleged to be caused by drinking such water.

*Iron* in quantity may produce headache and dyspepsia.

Brackish water from wells near the sea may set up diarrhœa.

Sulphurous acid in water is injurious to health.

*Action of water on lead.*—Those waters *act most* on lead which are the purest and most highly oxygenated.

Those containing

(*a*) Organic matter.

(*b*) Nitrites (especially ammonium nitrite; lead nitrite is formed, then lead carbonate, and nitrous acid is set free to act on another portion of lead; it exists in most distilled water).

(*c*) Nitrates (modified or arrested by the presence of carbonates or sulphates).

(*d*) Chlorides.

(*e*) Free sulphuric acid derived from iron pyrites.

(*f*) Vegetable and fatty acids from fruits, vegetables, sour milk, cider, etc.; and from decaying vegetation.

(*g*) Pieces of loose mortar.

Solution of the lead is also produced by galvanic action, which is set up by the juxtaposition of other metals, and by bending lead pipes against the grain, exposing the structure.

Lead is also taken up by water from zinc pipes. The deposit in lead pipes consists of carbonates, phosphates, and sulphates of lead, calcium and magnesium (if the water contained these salts), and lead chloride: this deposit may be broken off and dissolved.

Those waters have the *least action* on lead which contain

(*a*) Carbonic acid (carbonate of lead is formed and acts as a protecting coating to the pipes, and prevents further action, but an excess of carbonic acid would dissolve it).

(*b*) Calcium carbonate, phosphate (great protective power), and sulphate (not so much).

(*c*) Magnesian salts and alkaline phosphates. Perfectly pure distilled water may take up lead.

(*d*) Silica.

*To prevent* the taking up of lead by water, various suggestions have been made, the most useful being in protecting the pipes by McDougal's bituminous coating, varnishing with coal-tar, coating with lead sulphide (Schwartz) by boiling in sodium sulphide. Block-tin is sometimes recommended.

The addition of quicklime (2 grains to the gallon) has been used to counteract acidity; and water passed through silica is found to have less action on lead than it h previously.

*Amount of lead allowable in drinking water.*—Any quantity over one-twentieth of a grain should be considered dangerous; some people are affected by less (one-hundredth of a grain). Wanklyn adopts one-tenth of a grain per gallon as justifying rejection of a water.

(2) *Vegetable* matters in water are in solution or suspension. Water brown from peat is not objectionable; it should not be stored in lead cisterns, and should be filtered before it is used; it has been known to cause diarrhœa. Water from marshes should be avoided, it may cause diarrhœa.

(3) Impurities of *animal* origin. The quality rather than the quantity seems to determine the danger. Water acts as the carrier of various diseases; it is necessary, therefore, that the specific cause be present. It is possible also that multiplication or development of such germs or their spores may take place in water. Thus in regard to *cholera* in 1886, the evacuations of the first two patients in the eastern district of London were received into the river Lea, from which soakage took place into the uncovered reservoirs of the East London Water Company; the epidemic which broke out was confined to the district supplied by the company.

Infection of enteric fever is more certain by water than by air.

Diphtheria, scarlet fever, yellow fever, and malarious diseases may be similarly conveyed. Ulcers and boils in the East have been ascribed to contaminated water.

*Diarrhœa* and dysentery may be produced. An epidemic of diarrhœa in a community is referable to air, water or food:

(1) If a number of persons are suddenly taken ill, it is probably one of the two last; and if spread over many families, it is almost certainly due to the water.

(2) Diarrhœa or dysentery constantly affecting a community, or returning periodically at certain times of the year, is due to water.

(3) A very sudden and localized outbreak of either enteric fever or cholera points to the water supply.

(4) The same applies to malarious fever.

(5) The general health is lowered by impure water.

*Entozoa, etc.*, may be conveyed by water :—

Ova of tænia solium and T. medicanellata.

Bothriocephalus latus (both eggs and embryo).

Distoma hepaticum (eggs developed in water).

Ascaris lumbricoides.

Dochmius duodenalis (Strongylus d. or anchylostomum d.).

Filaria dracunculus, or guinea worm.

Filaria sanguinis hominis. The embryo is taken into mosquito's stomach with blood of persons infected with this parasite ; it begins developing and is then transferred to water and so back to man.

Bilharzia hæmatobia.

Leeches attach themselves to the throat and larynx and produce bleeding and emaciation.

## The Purification of Water.

Nature purifies water from vegetable and animal matter by decomposition and oxidation, aided by subsidence and filtration through porous strata, and also by evaporation and condensation.

Artificially, water may be purified by

(1) Distillation.

(2) By precipitating injurious matters by addition of various ingredients, by boiling, etc.

(3) By filtration.

1. *Distillation* will ensure pure water if properly carried out. The water should always be tried with a few drops of dilute nitric acid and silver nitrate before use ; if no haze is produced the water may be safely taken.

Precautions.—Aërate water ; it will not keep good long ; avoid lead in the apparatus, and take care foul water does not leak through.

2. (*a*) *Boiling* gets rid of calcium carbonate, hydrogen sulphide, and lessens organic matter and iron. Repeated boilings will destroy micro-organisms.

(*b*) *Exposure* to air in divided currents, as through a sieve, removes hydrogen sulphide, offensive organic vapours and perhaps dissolved organic matters.

(*c*) *Aluminous salts* act well if calcium carbonate be present; a sulphate is formed, and with a bulky hydrated alum precipitate floating matters are carried down. To a gallon of water add six grains crystallized alum, adding first, should the water be soft, a little chloride of calcium and sodium carbonate. If Bird's Patent Fluid be used (ter-sulphate of aluminium) twenty drops are added to a gallon.

(*d*) *Lime* (Clark's process) combines with carbonic acid and is precipitated with the calcium carbonate already in the water, carrying with it suspended matter and some dissolved organic matter and iron. Arrests organisms. Does not affect sulphates and chlorides of calcium and magnesium. On a large scale Atkin's modification is used.

(*e*) *Sodium carbonate* throws down sulphate of lime, leaving sodium sulphate in solution, and lead if present.

(*f*) *Potassium or sodium permanganate* removes the offensive odour of impure water kept in casks, etc.; of hydrogen sulphide; suspended matters are carried down by the manganic oxide precipitate. Gives a yellow tint to some waters from presence of finely divided manganese peroxide; it is not injurious, but may be removed by addition of alum or by filtration. Add Condy's Fluid, a teaspoonful at a time, to three or four gallons of water until a faint purple tint appears and remains for some hours. As a preliminary to the alum process it is useful.

(*g*) *Perchloride of iron* purifies turbid waters from clay, etc. To a gallon of water add two and a half grains of the solid perchloride.

(*h*) *Strychnos potatorum* is used in India; probably carries down suspended matter.

(*i*) Iron wire and magnetic oxide of iron are said to remove organic matter.

(*j*) Immersion or boiling in the water of certain vegetable bodies, especially such as contain *tannin;* tea, kino, bitter almonds, etc., have been used.

(*k*) *Charring* the insides of casks is a simple plan, and can be repeated when necessary.

(*l*) Agitation with small fragments of coke, spongy iron or scrap iron purifies from organisms (Frankland).

To sum up, impurities are most readily removed thus:

| | |
|---|---|
| Organic matter by | Distillation, boiling, exposure to air, alum, permanganates, tannin, and by agitation with coke, etc. |
| Carbonate of lime by | Boiling, and addition of caustic-lime. |

Iron by—Boiling, lime, and in part by charcoal.

A combination of alum, lime, and sodium carbonate removes the temporary and even reduces the permanent hardness somewhat.

3. *Filtration* is used on a large scale in connection with water supplies to towns, etc. After the water has stood for some time in a settling tank to allow the more bulky substances to subside it is led to filters composed of sand and gravel, and through these it passes either by ascent or descent. The component parts vary according to the quality of the water, but the following is an example of the manner in which a filter is made:

Beginning at the bottom there are 1 foot to 2 feet 6 inches of rough stones, getting smaller towards the top, 3 to 6 inches of gravel, $\frac{1}{2}$ to $\frac{3}{4}$ inch of shells, 3 to 6 inches pea gravel, $1\frac{1}{2}$ feet to $4\frac{1}{2}$ feet of sand. The top layer should be a fine silicious sand, which can be removed and washed as often as is necessary. For water containing much organic matter, as at Wakefield, it is found that a second filtration through a bed consisting of 4 inches of gravel at bottom, 15 inches Spencer's Magnetic Carbide, and 9 to 15 inches of fine sand at top, turns out a water which is bright and clear. The pressure of water is kept low, the depth not being more than 1 to 2 feet. The water must not pass through the filters at a rapid rate. This varies with the quality of the water from 300 to 800 gallons per square yard per twenty-four hours. In the latter case, of course, the water is comparatively pure to begin with.

*Results.*—The larger particles are obstructed while the finer adhere to the sand and stones.

Organisms are removed for the first week or two by sand, especially the green ferruginous variety (P. Frankland). Dissolved mineral matter with lead and sodium chloride are removed when the sand is in thick layers and cleansed frequently; colour is lessened, and oxidation of organic matters may take place.

*Small and domestic filters.*—Essentials of a good filter:

(1) Every part must be easily accessible for cleansing; cemented-in blocks are bad.
(2) The medium must have sufficient purifying power chemically on organic matter in solution, and be able to arrest organisms and their spores, and must be present in sufficient quantities.
(3) The purifying powers must be reasonably lasting.
(4) The medium must yield nothing to the water that may favour the growth of low forms of life.
(5) There must be nothing in the construction of the filter that can undergo putrefaction, as sponge, cotton, etc., or can yield metallic or other impurities to the water.
(6) The filter must not be liable to clog, and must deliver the water at a reasonably rapid rate.

There are numerous forms of filters, as the charcoal, the spongy iron, the carbide of iron.

*Animal charcoal* is deprived of its calcium phosphate and carbonate by hydrochloric acid and water. It should be arranged so that the water passes through slowly (there should be contact for four minutes).

At first organic and mineral suspended and dissolved matters are removed, but this power ceases in about twelve days if charcoal be used alone.

The water must not be allowed to stand in contact with the charcoal, and must be used soon after filtration as it takes up phosphate from the charcoal, upon which low forms of organic life derived from the air or from the charcoal can feed. Organisms may pass through unchanged; therefore, if charcoal be used alone, it will not remove disease poisons. Organisms are removed in some filters by an asbestos strainer, and in others by one of natural stone. It is not good for using on a large scale nor for placing in cisterns.

*Vegetable charcoal* is inferior in efficacy.

*Coke* is equal to animal charcoal at first and retains its powers longer, but the organic constituents are not much affected chemically.

*Silicated* carbon is the residue of a bituminous shale, and consists of silica and coke; it, as well as ordinary charcoal, is formed into blocks, but there is not sufficient quantity and it is apt to clog. Filters clog less if the material used is loose and in small particles. Blocks are apt to crack and allow unfiltered water through.

*Spongy iron* (Bischoff) is obtained by roasting hæmatite iron ore. It acts mechanically and chemically, arrests the suspended matter, and slowly oxidises organic matter held in solution, and removes lead. It does not remove micro-organisms. It retains its power a long time—at least a year. Water will not deteriorate if left in contact or stored. Spongy iron may cake, but this may be prevented by having a strainer if the water has much suspended matter. The water does not run through so quickly as with a charcoal medium, and it may yield a little iron to the water. This is removed in such filters by passing the water through a sand mixed with pyrolusite (native manganese oxide).

Filters containing magnetic oxide or carbide of iron may be looked upon as similar in action.

The Chamberland filter used by Pasteur consists of a polished cylinder of porcelain through which the water is forced. No effect is produced on the chemical constituents in solution, but it strains off all organisms and suspended matters.

*Cisterns and pipe filters* are objectionable; they are too small for the work as a rule. A much better plan would be to have an ordinary large filter attached to supply-pipe and fitted with a ball-cock or self-feeding valve.

*Cleansing of filters.*—No filter is self-cleansing. Before use filters should be well washed. Sooner or later all filtering media not only cease to be efficient but even give off impurities to the water, and must periodically be cleansed or renewed.

*Animal charcoal* may be heated to redness under cover and then washed with distilled water. If this cannot be done, then boil with or without permanganate of potassium, adding a little mineral acid (25 grains of permanganate with 10 drops strong sulphuric acid to quart of water). Afterwards wash in diluted muriatic acid to dissolve the manganic oxide. After this it may be exposed to the sun and air, washed and used again.

Block filters may be brushed and treated as described above. After the boiling pass through the muriatic acid solution (ʒii. to the gallon) and follow it with three gallons of distilled or good rain water.

Asbestos can be heated to redness. Sandstone strainers may be scrubbed with hot water with soda or boiled.

Pocket filters require frequent brushing and cleansing.

Spongy iron may be cleansed by heating to a low red heat and washing afterwards.

The Chamberland filter may be cleansed by boiling and brushing the outside, or it may be heated in a stove or gas flame.

## Examination of Water.

Water is examined by physical, chemical and biological methods.

*Collection of Samples:*

The quantity should not be less than half a gallon.

A 'Winchester quart' glass-stoppered bottle is the most convenient bottle to use. It must be thoroughly cleansed before use, and before being charged it should be rinsed out with some of the same kind of water as that which is to be analyzed. When charged the bottle should not be quite full, and should have the stopper or clean new cork tied over with a piece of clean linen, calico, leather, bladder, or india-rubber, and the string sealed against the bottle.

Keep samples in cool dark place, and examine within forty-eight hours if possible.

Full information should be sent with the sample concerning the water, its surroundings, place, time and method of collection, note of any disease attributable to its use, etc.

**Good drinking water** should have the following characteristics :

*Physical :*

Colour.—When seen through a depth of one or two feet it should have a bluish or grayish appearance ; if of peaty origin, it may be yellow.

Clearness.—Should be transparent.

Brilliancy or lustre should be well marked. It is a guide to the aëration of the water, and the comparative terms *nil*, dull, vitreous and adamantine are used to denote the amount of lustre.

Taste.—There should be none except what is due to the gases dissolved. Wanklyn has suggested the addition of 50 grains of sodium chloride per gallon to suit some people's taste.

Sediment.—No sediment or suspended matter but what rough filtration will remove.

Smell.—None, either cold or warmed, or on addition of KOH.

*Chemical constituents ; permissible amounts :*

Total solids should be not more than 30 or 40 grains per gallon.

Chlorine should be under 3 grains, but 5 to 10 grains per gallon need not prevent the use of water except under certain suspicious circumstances.

Nitrates.—A trace. They afford no data of any value in judging of the organic quality of a water.

Nitrites.—None.

Albuminoid ammonia.—Water giving 0·00 parts per million may be passed as organically pure, even though much free ammonia and chlorides be present ; thus many deep well waters contain ammonia and nitrates, but they contain no organic matters, showing at once that there has been no previous pollution by sewage. Water may be passed as good if free ammonia be absent, or very small in amount, with as much albuminoid ammonia as 0·1 per million (·007 grains per gallon). Water is suspicious with much free ammonia along with more than ·05 parts per million of albuminoid ammonia.

Much organic impurity is probably of vegetable origin, if chlorine be less than 1 grain per gallon.

Free ammonia should be under ·0035 grains per gallon. Much of the 'free ammonia' is derived from urea. Urea is only found in water very recently contaminated, for it speedily becomes carbonate of ammonia.

Nitrogen compounds expressed as 'organic nitrogen' should not be more than ·023 parts in 100,000.

Organic carbon should not be more than 0·2 parts per 100,000.

Oxygen absorbed by organic matter within half an hour by permanganate and acid at 140° F. should be under 0·07 grains per gallon.

Hardness total should be under 12° (Clark).

Hardness fixed should be under 4° (Clark).

Phosphoric acid in phosphates—traces.

Sulphuric acid in sulphates—under 2 grains per gallon.

Iron—traces—under two-tenths of a grain per gallon.

Hydrogen and alkaline sulphides—*nil*.

*Microscopic characters* (600 to 1,200 diameters) :

Mineral matter ; vegetable forms with endochrome ; large animal forms ; but no organic *débris*, as muscular fibre, spiral vegetable fibres, epithelium, wheaten or potato starch cells, cotton or linen fibres ; and no fungi or bacteria. (Sewage matters have a dark reddish brown or reddish colour, and are in globular masses, while decomposing vegetable matter is flatter and more spreading. mineral particles are angular, clay and marl round smooth globules, unaffected by acids ; chalk smooth and crystalline, soluble with effervescence in acids ; iron peroxide, reddish brown amorphous masses, soluble in HCl, and turning deep blue with ferrocyanide of potass.)

*Biological characters :*

No definite rule as yet ; the fewer organisms the better, especially when they liquefy the medium in which they are grown.

The *biological examination of water* is carried out as follows : a known quantity of the water is mixed with liquefied sterilized nutrient gelatine, and poured on a glass plate, covered with a bell-jar, and kept at a constant temperature for a few days when the germs have developed into colonies, which may be counted and their characteristics noted. If liquefaction of the gelatine be produced round a colony, it does not necessarily show that the germs there are pathogenic. Under the microscope the colonies may be separated into the different varieties of bacteria, moulds, or fungi. To distinguish which are pathogenic, pure cultivations must be made of each colony separately, and animals inoculated therefrom (Klein).

**Water is examined chemically:**

(1) Qualitatively.
(2) Quantitatively.

Candidates are expected to know the methods used in the latter, but have not generally to analyze water other than qualitatively.

*Qualitative analysis:*

Note first the presence or absence of the various physical characteristics already mentioned.

Use litmus and turmeric papers and note reaction. If acidity disappears on boiling it is due to carbonic acid. If alkalinity disappears on boiling it is due to ammonia. If permanently alkaline, to sodium carbonate.

It is advisable to concentrate a portion of the water to be examined to one-fiftieth in the porcelain dish, otherwise important ingredients, as lead, zinc, or nitrates in minute quantities, might be overlooked.

Re-agents and the necessary appliances are provided (anything required is usually supplied on demand), but candidates will do well to provide themselves with a piece of platinum foil and some blue glass. Dip the platinum wires into acid and hold them in flame to cleanse from soda before making the flame test.

If the following tables be worked through systematically nothing will be missed, and the specimens of water will be easily examined in the allotted time.

State the various steps taken in making analyses, even if there are no results. Sometimes distilled water forms one of the samples.

*Table for the Detection of the Base in Solution.*

1. To portion of original solution (O.S.) add a few drops HCl.

*White* precipitate means :

**Pb** soluble in boiling water. O.S. + $K_2CrO_4$, yellow ppt.

**Ag** } insoluble in boiling water.
**Hg (ous)** } insoluble in boiling water.

**Sb** } soluble in excess.
**Bi** } of dilute HCl.

2. If no precipitate, or the precipitate is soluble in excess of dilute HCl, pass $H_2S$ through the same solution.

*Black* precipitate means :

**Cu** O.S. + $NH_4HO$, light blue ppt. soluble in excess forming dark blue solution.
O.S. + $K_4FeCy_6$, reddish brown ppt.

**Hg (ic)** O.S. + $NH_4HO$ white ppt. O.S. + KI, red ppt.

**Pb** O.S. + $NH_4HO$, white ppt. O.S. + KI, yellow.

**Bi** O.S. + $NH_4HO$, white ppt. O.S. + KI, green or brown ppt.

*Brown* precipitate means :

**Sn (ous)** soluble in $NH_4HS$, reprecipitated yellow on addition of dilute HCl.

*Yellow* precipitate means :

**Sn (ic)** soluble in $NH_4HS$, and soluble in strong HCl.

**As** soluble in $NH_4HS$, insoluble in strong HCl.

**S** may be precipitated in groups 1 and 2, white or light yellow. It does not answer confirmatory tests.

*Orange* precipitate means :

**Sb** soluble in $NH_4HS$.

(Reinsch's and Marsh's tests for **As** and **Sb** should be known, but time is not given in the practical examination to perform the various processes. Add O.S. and HCl to test tube containing piece of **Cu** wire heat = grey deposit on wire ; treat the copper in a Marsh's apparatus, when the deadly vapour of arsenuretted or antimoniuretted hydrogen will pass off, light it, and hold a piece of cold porcelain in the flame ; a black deposit will be produced. Pour some solution of chlorinated lime on the deposit ; if soluble, it is arsenic ; insoluble, antimony. If another piece of the copper wire be dried and heated in a dry test-tube, the deposit will sublime and condense on the sides of the tube in octahedral crystals if arsenic, in amorphous form if antimony.)

3. If no precipitate with group 2 to the same solution, add $NH_4HO$, $NH_4Cl$ and $NH_4HS$, and warm.

*Black* precipitate means :

**Fe** (ous) To neutral solution add potassium ferrocyanide, white ppt. turning greenish blue and then light blue.

O.S. + potassium ferridcyanide dark blue ppt. (Turnbull's blue).

O.S. + KOH, pale green ppt., changing to black and brown.

**Fe** (ic) O.S. + potassium ferrocyanide dark blue (Prussian blue), insoluble in acids.

O.S. + potassium ferridcyanide darkened, but no ppt.

Aqueous solution of $K_6Fe_2Cy_{12}$ quickly decomposes, forming a little ferrocyanide, which will produce a green colour in this last test.

O.S. + KOH, deep red-brown ppt.

*Flesh*-coloured precipitate means chromium.

*Green*-coloured precipitate means manganese.

*White* precipitate means :

**Zn** O.S. + $NH_4HO$, white ppt. soluble in excess.

O.S. + $K_4FeCy_6$, white ppt.

O.S. + KOH, white ppt. soluble in excess ; is not re-ppt. on adding $NH_4Cl$.

O.S. evaporate to dryness on platinum foil, add drop nitrate of cobalt, a green colour is produced.

**Al** O.S. + $NH_4HO$, white ppt. insoluble in excess.

O.S. + $K_4FeCy_6$, no ppt.

O.S. + KOH (a few drops) white gelatinous ppt. soluble in excess, and re-ppt. on adding $NH_4Cl$ freely.

O.S. evaporated to dryness and treated with nitrate of cobalt produces a blue colour.

4. If no precipitate with group 3 add to the same portion of water $(NH_4)_2CO_3$.

*White* precipitate means :

**Ba** O.S. + $K_2CrO_4$, yellow ppt. Apply O.S. to flame on platinum wire, green colour.

**Ca** O.S. + $K_2CrO_4$, no ppt. O.S. + $CaSO_4$, no ppt.

O.S. + Ammon. oxalate, white ppt.

Platinum wire dull brick-red coloured flame.

5. If no precipitate with 4 to O.S. add $Na_2HPO_4$, $NH_4Cl$ and $NH_4HO$.

**Mg** gives a white ppt., falling slowly in dilute solutions.

6. If no precipitate with 5 add a strong solution of tartaric acid $(H_2C_2H_4O_6)$ to O.S.

*White* precipitate means :

**$NH_4$** O.S. + a few drops Nessler's solution brown ppt. of dimercuric ammonium potassio-iodide or yellow colouration with small amounts of ammonia.

O.S. + KOH, boil, pungent odour, and moistened red litmus paper held over tube will turn blue.

**K** Apply to flame on platinum wire pale violet colour ; best seen through two pieces of blue glass.

*No precipitate* may mean :

**Na** Applied to flame on wire, yellow colour.

**Li** Applied to flame on wire, crimson colour.

*Table for the Detection of the Acid in Solution.*

**Sulphates** :

O.S. + $BaCl_2$, white ppt. insoluble in strong HCl. Should solution have been proved to contain Ag Pb or Hg (ous) they must be eliminated with $H_2S$ and solution boiled.

**Chlorides** :

O.S. + $AgNO_3$, white ppt. insoluble in dilute $HNO_3$; soluble in dilute ammonia.

If candidate has time to spare at an examination, he may readily estimate the amount of chlorides in the water in the manner given below.

**Nitrates :**

O.S. + pure $H_2SO_4$ and crystal of brucia turns pink, or with solution of brucia a pink and yellow zone.

O.S. + equal bulk $H_2SO_4$, wait till cold, then float on surface $FeSO_4$; a dark olive zone results.

**Nitrites :**

O S. + KI and solution of starch, acidulate with dilute $H_2SO_4$; immediate blue colour results.

O.S. + solution of meta-phenylene diamine =yellow colour (let it stand twenty minutes). Brownish gas comes off on adding $H_2SO_4$.

**Carbonates :**

O.S. evaporate to dryness and add HCl, effervescence occurs. Pass this colourless, odourless gas into lime water, causes white ppt. Carbonates give an immediate ppt. with magnesium sulphate. Bicarbonates do not.

**Phosphates :**

O.S. + $NH_4Cl$ + $NH_4HO$ + $MgSO_4$ = white ppt. If solution of phosphate be dilute the ppt. requires some time to form.

O.S. + ammon. molybdate + $HNO_3$ dilute, boil, yellow ppt.

**Sulphides :**

O.S. + few drops dilute HCl, $H_2S$ is evolved and may be recognised by its odour.

Moist acetate of lead paper held over tube turns black.

O.S. + nitroprusside of sodium, violet purple colour will show sulphides to be alkaline, no colour but ppt. with lead means $H_2S$ uncombined.

Acetates :

O.S. + alcohol (S.V.R.) + $H_2SO_4$ warm, and acetic ether is evolved.

(Acetate of lead may be put in water for examination purposes.)

In stating the results of analysis, each metal and acid radical may be stated separately ; but it is better to distribute the acids and bases so that the acid gets the bases for which it has most affinity. The chief salts will be found to be calcium carbonate and sodium chloride.

*Quantitative Analysis :*

*Total solids* are determined by evaporation of a known quantity of water (usually 70 c.c.*) to dryness at a moderate heat in a platinum dish, the weight of which has been previously ascertained ; the residue which adheres to the dish after evaporation is then weighed with the dish—the difference will, of course, represent the solids of the water. The residue consists largely (as a rule) of carbonate of lime, which will effervesce on the addition of a drop of hydrochloric acid.

The dried solids are now incinerated, the *volatile solids* are driven off, and the *fixed solids* remain. Not more than 1·5 per 100,000 ought to be volatile. (Little importance is attached to this now, for the loss does not represent organic matter only, as was at one time believed.) The solids should blacken very little on ignition, unless the water be from peat-land.

*Chlorine* is determined thus : To a given quantity of water (to which has been added a small quantity of yellow chromate of potassium) silver nitrate (4·79 grammes to a litre of water) is dropped and stirred up after each addition ; the red silver

* Seventy cubic centimètres of water weigh 70,000 milligrammes, and as one gallon weighs 70,000 grains, seventy cubic centimètres is a sort of miniature gallon wherein the milligramme corresponds to the grain. If we know the number of milligrammes of residue which seventy cubic centimètres leave, we know also the number of grains of solids in a gallon of water.—*Wanklyn.* To obtain parts per 100,000, multiply grains per gallon by 10 and divide by 7.

chromate will disappear so long as any chlorine is present. Stop when the red tint becomes permanent; as 1 c.c. of the silver nitrate equals 1 milligramme of chlorine, the chlorine in the amount of water taken can be calculated. Neither the water nor the nitrate of silver solution must be acid, else the silver chromate will be dissolved.

*Hardness* is ascertained by Clark's soap test.—Rationale: When an alkaline oleate is mixed with pure water, a lather is formed; but if lime, magnesia, iron, alumina, etc., be present, more of the oleate in varying quantities will be required to form a lather.

To determine *total hardness*.—70 c.c. are put in a stoppered bottle and standard soap solution added, the bottle being well shaken after each addition; when a thin, beady lather is produced over the whole surface and remains permanent for five minutes the process is complete.

From the number of cubic centimètres (or 'measures') used, deduct one, the amount necessary to give a lather with 70 c.c. of pure water. Then as 1 c.c. corresponds to 1 milligramme of calcium carbonate, the number of measures used is the number of milligrammes of calcium carbonate in the 70 c.c., or the number of grains per gallon. The result may be expressed as parts per 100,000, or as degrees of Clark, in which a degree represents a grain of calcium carbonate per gallon. If expressed metrically, the result may be converted into degrees (Clark) by multiplying by 0·7.

*Permanent or fixed hardness.*—Boil the water and use soap test again. The result will represent the permanent hardness due to calcium sulphate, and chloride and magnesian salts. The difference in the results of the two tests represents the

*Temporary or removable hardness.*—It is this which causes the 'fur' in boilers. Each degree of hardness implies the waste of about 12 lb. of the best hard soap for each 10,000 gallons used in washing. The soap test has also been used to determine approximately the amounts of lime, magnesia, free carbonic acid, and sulphuric acid in water thus:

*Lime.*—Take total hardness; then precipitate lime by ammonium oxalate and test again; the difference will be due to lime.

*Magnesia.*—Boil water from which lime has been eliminated, the result of the soap test will represent magnesia (Boutron and Boudet).

*Earthy and alkaline carbonates* (Mohr's process) may be also determined by noting the quantity of a standard solution of sulphuric acid required to turn yellow a water to which a proportion of cochineal or phenol-thallein has been added.

*Free carbonic acid.*—Eliminate lime as above; test; then water freed from lime is to be boiled and tested; the difference will represent the carbonic acid driven off.

*Sulphuric acid* is determined by the use of a solution of nitrate of barium. The hardness (supposing no $SO_4$ present) would be equal to the original hardness of the water, plus that of the baryta solution; but $SO_4$ being present, barium sulphate is precipitated, and there is a loss of hardness.

**Organic matters** found in water may be of animal or vegetable origin; the former may be distinguished from the latter, which is comparatively harmless when in excessive amount by being accompanied by large quantities of total solids, chlorine and ammonia; and also by the other methods, physical and microscope, used in the examination of water.

Under the term 'organic matters' are included:

(1) *Nitrogenous and organic matters*, and (2) *Oxidisable organic matters*, chiefly non-nitrogenous.

There are two methods in use to determine the nitrogenous organic matters; these are the *albuminoid ammonia process* of Wanklyn, and the *organic carbon and organic nitrogen process* of Frankland.

**The albuminoid ammonia process.**

The following are the reagents required:

*Nessler's solution.*—35 grammes of potassium iodide, and 13 of corrosive sublimate are added to 800 c.c. of distilled water, which is heated to boiling until the salts dissolve; then add a cold saturated solution of corrosive sublimate until the red per-iodied of mercury just begins to be permanent. To render it sensitive add 160 grammes of caustic potash, or 120 of caustic soda, and make up with distilled water to 1 litre.

*Dilute standard solution of ammonia*, of which 1 c.c. = 0·01 milligramme of ammonia or 0·0082 milligramme of nitrogen.

*Alkaline potassium solution.*—200 grammes of solid potash, and 8 grammes of pure potassium permanganate are boiled in 1,100 c.c. of distilled water till concentrated to 1 litre.

Each analysis requires 50 c.c. of this solution, that is, 10 grammes of potash, and 0·4 of permanganate.

*Distilled water* for making up standards of ammonia. Must be very pure. Should be distilled with a little phosphoric acid to fix ammonia (Notter).

**The process**—(*a*) *Free ammonia.*—250 c.c. of the water to be examined is placed in a retort attached to a Liebig's condenser (the apparatus being scrupulously clean), and 50 c.c. are distilled over and collected in a cylinder.

Experience shows that three-fourths of the whole 'free ammonia' is contained in the first 50 c.c. Therefore Nesslerize the first 50 c.c., and add one-third to the result.

The 'free ammonia' is that which is combined with carbonic, nitric or other acids, or other easily decomposable substances.

(*b*) *Albuminoid ammonia.*—The bulk of the nitrogen left in the water is now broken up and converted into ammonia.

After the free ammonia has been determined, the process is continued, and 100 c.c. more are distilled over and thrown away; 25 c.c. of the alkaline permanganate solution is then added, and distillation is allowed to proceed slowly, the distillate being collected in successive quantities of 50 c.c. until no more ammonia comes over.

*Nesslerizing* is the operation of finding the strength of dilute solutions of ammonia by help of the Nessler test. To 50 c.c. of distillate, add 2 c.c. of the Nessler reagent; if ammonia be present, the distillate will assume a rich brown colour; the more the ammonia the deeper the colour.

Next a clean cylinder is taken, and into it is dropped a certain measured volume of the dilute standard solution of ammonia, and filled up with distilled water to 50 c.c. To this 2 c.c. of Nessler reagent is now added ; if the colour produced is the same as that of the tested distillate, then the test is completed ; the number of c.c. of ammonia solution represents the ammonia or nitrogen in the distillate. If the two solutions are not of equal depth of colour, another standard one must be made up, and another comparison made until the colours are of the same depth. Each 50 c.c. of distillate after the addition of the permanganate must be tested until no colour is produced, and the amounts must be added together ; the total represents the 'albuminoid ammonia.'

**Organic carbon and organic nitrogen process.**

Frankland determines organic matter by destroying the nitrates by the aid of soda sulphate, evaporating to dryness, and burning the residue with oxide of copper and lead chromate ; the *nitrogen and carbonic acid* are then estimated.

The lower the ratio of C to N, the more objectionable is the condition of the water ; thus 3 to 1 is worse than 10 to 1.

Sewage is less than 3C to 1N.

Good drinking-water should not be less than 7C to 1N.

The term 'total combined nitrogen' includes organic nitrogen and nitrogen, as nitrates, nitrites and ammonia.

Comparison of the two methods : Frankland's is a much more tedious and difficult process than Wanklyn's, hence more liable to error.

In the Frankland process there is a risk that the organic matter may be destroyed during the evaporation to dryness, or by the preliminary destruction of the nitric acid. The small quantity of organic matter existing in water is insufficient to admit of a correct organic analysis.

To Wanklyn's process the objection is taken that the proportion of ammonia evolved varies widely with the different kinds of organic matter submitted to the reaction, but it is claimed that the 'albuminoid ammonia' can be looked upon as an index to the nitrogenous organic matter, as valuable in itself as a determination of the total nitrogen would be, and more valuable in the certainty with which the results can be obtained. The 'albuminoid ammonia' is not the total amount of ammonia which the albumen is capable of giving, but is about two-thirds of the total quantity; this is, however, a constant fraction.

*Nitrates and nitrites* are produced by the passage of sewage through earth, ammonia being changed first to nitrites, and then to nitrates, by the action of certain micro-organisms; but the presence of nitrates cannot be taken as necessarily pointing to sewage contamination, as many pure waters are often highly charged with nitrates from the passage of the water through geological strata containing nitrates; such waters have no organic impurity. Nitrates are removed by the processes of vegetation.

Nitrates may be estimated:

(1) By Wanklyn and Chapman's modification of Schultze's process. Nitrates are converted into ammonia by means of metallic aluminium acting upon them in a cold alkaline solution. The liquid is then distilled and Nesslerized.

(2) Or by the copper-zinc process; zinc foil is immersed in a solution of copper sulphate until the zinc is covered with a deposit of copper (it is known as a 'wet copper couple'); a piece of this is put with the water to examine, and after ten or twelve hours, when the nitrous acid has gone, the liquid is distilled and Nesslerized, and the amount of nitric acid calculated from the ammonia, any nitrous acid or ammonia already determined being deducted first.

(3) Or by evaporating a small amount of water to dryness, adding sulphuric acid, phenol and hydrochloric acid, warming and then neutralizing with caustic potash; pure water is then added, and the colour of the solution compared with that of a standard solution.

*Nitrites* may be estimated by means of solutions of meta-phenylene diamine and sulphuric acid, producing a red colour, which is to be compared with a standard as in the Nessler process (Griess), or they may be determined by the permanganate process (see below).

2. **Oxidisable matter** may be ferrous salts, hydrogen, sulphides, nitrites or organic matter.

The former two can easily be detected; the two latter are the more important, and may be estimated by the use of standard solutions of permanganate and sulphuric acid solutions.

To differentiate, the solution is boiled with sulphuric acid, and after cooling permanganate is added as before. If the action is rapid, animal matter is probably present; if slow, vegetable. The oxygen used is the amount required for the oxidation of the organic oxidisable matter, and is called *organic oxygen*.

The surplus oxygen in the first part of the process represents *nitrous acid.*

**1** c.c. of permanganate solution yields with acid 0·1 milligramme of oxygen, while with an alkali only 0·06 of oxygen is given up.

*Chloride of gold* may be used to detect the presence of oxidisable matters; the water should be neutral or feebly acid, and must be boiled for some minutes with the reagent. The colour changes from rose pink to violet, then to olive, and there may be a black precipitate. If no nitrous acid be present, the reaction may generally be considered due to organic matter.

It is useful in deciding between ammoniacal deep-spring and sewage polluted waters to know the oxygen required.

*Phosphates* may be present in water where there is sewage pollution, but they seldom exist, except in the smallest traces, as phosphates, being acid salts are incompatible with calcium carbonate.

*Poisonous metals.*—Lead, iron, and copper are the poisonous metals more usually met with in drinking-water; less than one-tenth grain of lead or copper, and not more than two-tenths grain of iron per gallon may be permitted.

The quantities of these metals present may be found by making use of the ammonium sulphide precipitation, and comparing with standard solutions. In practice, a glass rod moistened with ammonium sulphide is dipped into some water in a porcelain dish; if there be any colouration, it should just be visible, and should disappear on the addition of two or three drops of hydrochloric acid if it be due to iron; if it remain, it is due to copper or lead, and should be condemned. Arsenic, barium, zinc, manganese, and chromium sometimes find their way into drinking-water from chemical and other works.

## CHAPTER III.

### REMOVAL AND DISPOSAL OF EXCRETA AND REFUSE, ETC., AND CLEANSING OF TOWNS.

It is essential that all refuse should be removed as speedily as possible from the vicinity of dwellings. These refuse-matters consist of fæces, urine, waste-water from houses and factories, washings from roadways, stables, etc., and of ashes, dust, road-sweepings, etc.

*Excreta* (human):

| | | | | | |
|---|---|---|---|---|---|
| Daily amount of solid excreta | per head | averages | 2½ | ozs. |
| „ „ „ „ | per male adult | „ | 4 | „ |
| „ „ fluid „ | per head | „ | 40 | „ |
| „ „ nitrogen | „ | „ | 150 | grs. |
| „ „ urea ($CH_4N_2O$) | „ | „ | 500 | „ |
| „ „ uric acid ($C_5H_4N_4O_3$) | per hd. | „ | 8½ | „ |

Fæcal matters and urine are acid at first, and will remain so without decomposition for some considerable time if they are kept separate; but if fæces and urine are mixed, decomposition with the formation of ammonium carbonate takes place within twenty-four hours.

Decomposition of fæces free from urine yields organic fœtid substances, but sulphuretted hydrogen is seldom present. When heated, carburetted hydrogen is given off largely. When urine or water is present: ammonia, light carburetted hydrogen, nitrogen and carbon dioxide are evolved; the liquid generally contains ammonia and sulphuretted hydrogen. Urea is the chief nitrogenous body present, but it is soon transformed into carbon dioxide and ammonia.

The waste-waters from the various sources stated above are often as foul as ordinary sewage.

The various plans for the removal of excreta may be primarily divided into two classes:

1. The water method.
2. The dry methods.

1. **The Water Method:**

Necessary conditions are a good supply of water, good sewers, ventilation, a proper outfall and means of disposal of the sewer water.

*Water.*—25 gallons per head per diem are required to keep ordinary well-laid sewers clean; but extra water has to be used from time to time for flushing purposes.

*House drainage.*—Water-closets should be placed in an outbuilding or projection from the house, with through ventilation between it and the house; the windows ought to open to the ceiling, or be ventilated through the roof by a tube. It is better to have a w.c. near the roof than in the basement.

Water-closets are of various kinds, but in all of them the essential thing is that they are *self-cleansing.* The old *pan-closet,* with a filthy container beneath, and an equally objectionable D trap between it and the drain, and the *long-hopper* closet, are still to be met with; neither form is self-cleansing.

Better forms are the short-hopper, the wash-out, the valve, the plug, and the trough.

A *short-hopper* closet should be a cone with a straight back, a circular flushing-rim, and fixed over an S trap 4 inches in diameter, with a water-seal of not less than 2½ inches, and an easy curve. The seat is often made hinged, so that the closet may be used as a urinal or slop-sink.

The water-supply should not be less than 2 gallons for each time of use; the amount and force should be sufficient to wash everything through the syphon. Water-waste preventing cisterns only should be connected directly with the supply of w.c.'s; the best are those that work by syphon action, one pull of the wire being sufficient to set it going; the cistern should be at least 4 feet above the pan.

The *wash-out* closet has a receptacle containing a little water to receive the excreta; the rush of water clears the contents of the basin over the edge into a short straight pipe leading to a syphon trap. They are not easily kept perfectly clean, even with more than 2 gallons of water at each flush, as the edge of the basin breaks the force of the water. In order that some water may remain in the receptacle, these closets are fitted with a small chamber which discharges some water into the basin when the main body of water has rushed away; this is called 'an after-flush.'

*Valve-closets* should have an overflow pipe which should be covered by the valve when open to prevent unsealing, or the overflow pipe should be led to the open air, so that water flowing from it would act as a warning. Waste-water preventing cisterns cannot be used with valve-closets, as they require from 6 to 8 gallons to properly cleanse them; there must also be an 'after-flush' produced as above, or by the use of a 'bellows regulator' working with the handle. A syphon or an anti-D trap should be attached to these closets. The 'safe-tray' beneath the basin should have the waste-pipe carried out to the open air.

The *plug-closet* consists of two communicating basins —one is the receptacle for fæces, the other is in connection with the drain, from which it is cut off by a plug attached to a handle; both chambers contain water, which is released by pulling up plug. A syphon-trap should be used to prevent passage of foul air when the plug is up. Like the valve, the plug is apt to become leaky, or to be obstructed by paper, hair, etc., especially if slops be emptied down them.

*Troughs* of cast iron or earthenware are found valuable in barracks, schools, model buildings of the poorer description, etc. The bottom should contain several inches of water throughout the whole length. A trough is best cleansed by the use of a Field's automatic flush tank, regulated to act as often as the necessity of the case requires. A syphon-trap covered with a grid to intercept brushes, cloths, etc., which may be thrown into the trough, should be placed between the trough and the drain.

*Traps* are only auxiliaries to a good drainage system (Eassie); reliance should not be placed in them solely.

Essentials of a good trap:

Must be *self-cleansing.*

Must be properly laid: the outlet must not be lower than the inlet.

Water must pass along frequently.

Water should stand at least three-quarters of an inch above openings.

Must be in proper proportion to the size of pipe; a too large trap will lead to deposit forming; too small a pipe running full will produce unsyphoning. A 4-inch trap is large enough for a 6-inch pipe.

Must not be forced by the pressure of sewer gas.

Varieties of traps, though numerous, may be classed into four groups:

(*a*) The syphon is a deeply-curved pipe like the figure S, in which the whole of the curve is always full of water; it is a good form of trap. Two syphons must not succeed each other in the same pipe, or one will suck the other empty. At the crown of the trap there should be an air-vent carried up into the soil-pipe, which is carried up above the eaves of the house; this will prevent syphoning, and will ventilate the trap. Should there be several traps on different floors one above the other, the action of the higher ones will unsyphon the lower unless the ventilating-pipes are arranged thus: 2-inch branch-pipes off the outer end of each trap join into one 3-inch main air-pipe, which is connected at its top to the soil-pipe above the highest w.c., the soil-pipe being carried full-size up to the roof.

Hellyer's 'anti-D' trap is a lead syphon-trap in which the calibre is diminished in the bent portion, and the end of the pipe beyond the curve is square instead of circular ; by the former the force of the water is increased as it passes through, and thereby cleanses the whole trap ; the square shape causes some obstruction to the water, and thus assists in the prevention of syphonage.

(*b*) The midfeather includes such objectionable traps as the dip, D, Bell, Antill, Liverpool, etc. They are not self-cleansing, and if not used regularly become dry and worse than useless.

(*c*) The flap-trap used to be put between the drain and the sewer, in the hope that it might prevent reflux of sewer air ; a brass flap may be put over the mouth of pipes opening over gratings to prevent cold air passing into the house, and to keep birds out.

(*d*) The ball-trap is one in which a ball covers an orifice, which it ought perfectly to block up, but as with the flap-trap, paper, etc., will easily prevent proper action.

Grease-traps are used in connection with kitchen-sinks, but are apt to be a source of nuisance if the decomposing fat be not frequently cleared out. For this purpose a syphon-trap answers well ; it should be provided with a screw-cap at the base of the curve, by which it may be cleansed.

For stables and yards a trap or gully should be used which will catch and deposit straw, etc. ; Dean's is a useful form, being provided with a movable bucket.

The *soil pipe* passes from the w.c. to the main drain of the house, and should be placed outside the wall ; it is also continued upwards to act as a ventilator in undiminished bore, and without avoidable bends, to 3 feet above the eaves of the roof, and the same distance above any window or opening in the roof, other than a chimney, from which it should be 6 feet distant. No rain-water pipe should be used either as a soil-pipe or as a ventilating shaft. Soil and ventilating pipes are made of iron coated in and out with Angus Smith's composition ; all junctions of closet and soil pipe and of the various lengths of soil and ventilating pipe must be securely made. Some recommend that traps with air inlets be placed at the foot of all soil-pipes as well as on the drain leading to the public sewer ; but this is not generally necessary.

Overflow and waste pipes from cisterns, tanks, urinals, lavatories, baths, safes of water-closets, sinks, etc., and all rain-water pipes, must not be connected directly with a drain, but must be taken through an external wall and empty in the open air over a grating covering a water-trap, or immediately under it ; but nothing must interfere with the passage of air through the grating to the openings of the pipes, and the grating must be so constructed that the aggregate extent of the apertures in it shall not be less than the sectional area of the pipes or drains to which it is fitted. All sink or waste or overflow pipes should be trapped.

The *house-drain* is the continuation of the soil-pipe, the junction being made by a curved pipe : no junction should be rectangular. It is advisable that it do not run beneath the house, but if it must do so, it should either be taken above the basement-floor and exposed to view, or it should be completely embedded in and covered with concrete at least 6 inches thick all round ; if not under a house, the drain should be laid on a concrete bed. Drains should be laid in straight lines. They may be of stoneware, but preferably of iron. Stoneware pipes are usually 4 to 9 inches in diameter—the smaller size being suitable for small houses, the larger for hospitals. They should be jointed with cement, unless Stanford's or Doulton's patent joints are used. Iron pipes, if coated in and out with Angus Smith's composition, will last fifty years or more (Corfield). In the 'Durham' system the interior of wrought-iron pipes is lined with asphalte, and the pipes are fitted with screw joints.

No pipe must join another at a right angle, either vertically or laterally ; curved or oblique junctions are necessary. An access-pipe is often included in the course of the house-pipe to the drain, and allows examination to be made easily.

| | | | | |
|---|---|---|---|---|
| Four-inch | pipes | require a | fall of | 1 in 40 |
| Six | ,, | ,, | ,, | 1 in 60 |
| Nine | ,, | ,, | ,, | 1 in 90 |

Should the fall not be sufficient, it is necessary to provide a flush tank. All drains and pipes should be washed out at least once a mouth.

The house-pipe must not enter the drain directly, but must have a good air and water trap intervening. Buchan's trap or Roger Field's disconnecting man-hole are good forms. It is most important that a good supply of fresh air enter the house-pipe so as to thoroughly ventilate the soil-pipe.

*Inspection and testing of drains :*

No drain should be passed as satisfactory without being inspected in its whole length before it is covered up, and without being tested, no matter how good the supervision of the workmen may have been.

*Tests* for drains :

For pipes that are exposed, smoke or volatile liquids are used ; for those below ground the water or air test is required.

Smoke test : Smoke is pumped into the ventilating-pipe at its lower end from a smoke-generating machine, or a smoke-rocket is put into the pipe ; the pipe is then closed and watched to see if any leakage occurs.

The peppermint test depends upon the pungent smell produced when oil of peppermint is mixed with hot water. The doors and windows being closed, and several persons stationed about the house to observe, and if possible locate the smell of the oil, half an ounce of peppermint oil is poured down the ventilating-pipe, followed by 4 gallons of boiling water ; the top of the pipe is then plugged, and in a few minutes the smell will be perceptible wherever there is a leakage.

Sanitas oil is employed similarly : about 4 oz. may be used ; it is much slower in showing itself, but the smell is not so disagreeable.

Water test : The lower end of the pipe is closed by having a Botting's Plug screwed in, or an india-rubber bag inserted and inflated ; the pipe is then filled with water : if it be sound the water will remain ; if not, it will sink, and an approximate conclusion as to the extent of the leakage can be come to from the rate at which the water sinks. Although a drain might prove leaky by the water test, it may not have been so before, as the pressure of the water may cause any weak parts of the jointing to give way ; the water test should be used periodically, as it is possible that in course of time a slight settlement might take place in the pipes with disturbance of the junctions.

The air test is a very difficult one to perform, as leakage is apt to occur. The pipe must be plugged ; air is pumped in and the pipe connected with a pressure-gauge, by which any escape can be detected.

When water is run down any house-pipe, even the soil-pipe, there should be no smell, if well ventilated and traps acting properly. It should be noticed whether the water runs away at once, or if there is any check ; and a light held over the entrance to the pipe or trap will show if there is any reflux of air, with or without water being poured down.

If the drain can be seen into, some lime mixed with water may be poured down the house-pipe, and its condition as to colour, flow, etc., noted at the opening.

If gas bubbles up on stirring the water in any trap, it shows great foulness, or else the trap is seldom used.

It has been suggested (Newton) that house-drains should be kept full of water always, and so obviate the necessity for ventilation, and remove the chance of sewer-air entering the house.

*Main sewers.* — Sewers are constructed according to the purposes they are to serve: they may carry off house and trade water, or solid excreta in addition, or one or both, with the rainfall. Sewers are made either circular or egg-shaped, of glazed earthenware, or of impervious brick moulded in proper shape and set in Portland cement; they are laid on a sound foundation, and arrangements are made to carry off subsoil water under the drain.

All drains should be accessible by man-holes, and be laid in straight lines from hole to hole; junctions of sewers and curves should be made at a manhole by means of open half-pipes. The radius of any curve should not be less than ten times the cross sectional diameter of the sewer.

Circular pipes are used when there is a *constant* flow of sewage sufficient to maintain the sewer half full, so that running nearly full the maximum flow of the place may be carried off.

Oval pipes are used when there is a *varying* flow. They are laid with the invert or small end down, because there is a greater depth of fluid with a smaller exposed surface; a maximum scouring effect is produced with a small quantity of water.

*Velocity of flow* in sewers should never be less than 2 feet per second, nor more than 4 feet per second. If less than the former deposits occur, and if more than the latter, the invert becomes quickly worn out. All the sewers in a system should have the same velocity—about 3 feet per second—throughout the whole course, and the fall requires to be equable and arranged according to the size of the pipe: thus the fall varies from 1 in 244 to 1 in 784.

In some districts it is impossible, from the uniform flatness of the ground, to get proper gradients, in which case special arrangements must be made; either locks or gates are provided to various sections of pipe, so that the contents may be retained for a time, and then being set free, suddenly they flush the next section; *or*, Field's Automatic Flush Tanks are used; *or*, Shone's Pneumatic Ejector is employed, as at Eastbourne, Southampton, Houses of Parliament, etc. Sewage flows into a chamber by gravitation, and is then forced by means of compressed air out through a discharge-pipe at a higher level. The ejector is also useful for discharging sewage into the sea against the rising tide, thus preventing the sewers being 'tide-locked.' The out-fall sewer need not be so large as when gravitation only is depended upon.

*To calculate discharge from sewers* several things must be known.

(1) *Hydraulic mean depth* = one-fourth diameter in circular pipes ; in pipes other than circular it equals the section area of current of fluid divided by the wetted perimeter (*i.e.*, that part of the circumference of the pipe wetted by the fluid). Error will be avoided if the hydraulic mean depth is reduced to a fraction of a foot.

Let V = velocity in feet per minute.
D = hydraulic mean depth.
F = fall in feet per mile.
A = section area of current of fluid.

Then $V = 55 \times (\sqrt{D \times 2\,F})$.

And VA = discharge in cubic feet per minute.

There is a point of flow in all sewers when they discharge more than when running full (Baldwin Latham). This is due to increased friction when running full, and to obstruction by air in the pipes.

*Deposits in sewers.*—The changing level of the fluid in the sewers leaves a deposit on the sides; while slimy matter swarming with bacteria and fungi collects on the crown of the sewers; this occurs even in well-made sewers; in badly constructed ones with improper falls, sharp curves, want of water, or from sinking of the floor or check of flow by tides, the deposits are much worse. A sewer should discharge itself in eight hours.

*Ventilation of sewers.*—No sewer is absolutely air-tight, and as the water-level is always varying, there must be provision for the admission and discharge of air. It has been usual to ventilate sewers by means of surface-gratings only; some of these will be inlets, others outlets. On main sewers there should be a grating every 50 or 100 yards, and care should be taken that these are large enough to allow free passage of air to and from the sewer, so that foul gases may be diluted. If the openings are too small or too few, they will act only as vents for the discharge of offensive air. Charcoal trays placed in the ventilators are of little use. The specific gravity of sewer air is less than that of the atmosphere, chiefly due to the diminution in the percentage of oxygen, which of the two chief constituents of both is much the heavier.

A better plan, especially in narrow streets, is to provide upcast shafts (one for every 20 feet of sewer), the surface-gratings would then act as inlets. It is difficult, however, to get permission to erect shafts in sufficient numbers to be useful; cowls do not as a rule give much assistance. Sewers then may be connected with factory-chimneys where the heat is utilized for the purpose of extracting the air, but this plan has the following disadvantages: The temperature of the chimney is not sufficient to destroy any noxious matter in the sewer gas; and the strong exhaust created may affect the drain-traps. Keeling's Sewer Gas Exhauster and Destructor has been found effective (Epsom, Richmond, and elsewhere). It consists of a hollow iron column like a lamp-post, with a gas-furnace of great heat in the base, through which the air from the sewer is drawn. It should be placed on the highest practicable gradients, especially at the end of cul-de-sacs, with openings at the lowest parts for the admission of fresh air. At Ealing twenty-five destructors efficiently ventilate 30 miles of sewers. Another plan consists in the placing of 'tumbling-bays' at intervals along a steep gradient; the air then is forced up the nearest ventilator instead of rushing up to the higher parts of the sewer.

The blowing off of steam, etc., and the blowing of the wind against the mouth of an open sewer increase the air pressure, and precautions should be taken to prevent traps being forced.

*The separate system* is a modification of the usual wet method of removing excreta, and is based on the principle of sending 'the rain to the river, the sewage to the soil.' It is a form of drainage recommended by Prof. Corfield.

Advantages: Smaller sewers, smaller amount of sewer water to be dealt with at the overflow, more fertilizing constituents, more regular flow, absence of débris from roads, storm waters do not flood the houses in the lower parts of the town, and if irrigation be the method of disposal of the sewage, heavy rains will not interfere with it.

Disadvantages: Two sets of pipes have to be provided; rain-water carries with it much organic débris from the air, roofs, yards, and streets, and thus pollutes streams; more flushing may be required for the sewers.

This system is valuable when a town is low, and it is expensive to lift sewage when land cannot be obtained; when the natural contour of the land is very favourable for the flow of rain in one direction, and of sewage in another. In countries with long dry seasons and heavy rainfalls, this system is too expensive.

*The interception system* is so-called because the solid excreta are retained in a perforated receptacle which allows the fluid part to drain away. This collection of filth in the basements of houses is most objectionable. This plan exists in Paris and other continental towns.

### *Disposal of Sewer Water.*

It is very often a difficult matter to decide in which way excreta and sewer water are ultimately to be disposed of. It is certain, however, that storage in cesspools, and discharge without purification into running water,* are plans which must be unhesitatingly condemned, although these means of disposal are to be found in many towns. The chief aim ought to be to remove all refuse matters as quickly as possible from the neighbourhood of houses.

Methods:

*Discharge into the sea.*—The outlet-pipe should always be under water, even at low water. If the sewage cannot be carried out well to sea, it will be thrown up on the beach and cause a nuisance. To ensure this, great care must be exercised in the selection of the site for the outfall, and observations should be made, not only of the surface-tides and currents, but also of those at different depths, and the effect upon the sewage by its different specific gravity from that of salt water must be allowed for, as well as the difference of level of the tides, and the configuration of the adjoining coast-line (H. P. Boulnois). In certain cases, therefore, the Local Government Board reserve the right to prohibit the passage of sewage into the sea.

When sewer-water passes into a river it undergoes purification by subsidence, by the influence of water

* *Vide* § 17, The Public Health Act, 1875.

plants, and in a lesser degree by slow oxidation of nitrogenous organic matters by aid of micro-organisms into nitrous and nitric acids and ammonia ; but ova, epithelium, etc., will be unchanged for long periods, hence river purification is not to be depended on.

The finely-diffused solid particles are hurtful to fish, choking their gills, while the water is deprived of the oxygen necessary for the fish.

Numerous devices have been resorted to with a view to get rid of the more solid part of the sewage and allow the fluid part to pass into streams or over land.* These plans may be arranged under the headings of :

Precipitation, Subsoil Irrigation, Filtration, and Irrigation.

The effluent water from any of these processes cannot be allowed access to streams unless it comes up to some standard of purity. The Rivers Pollution Commissioners recommend that 100,000 parts of effluent water should not contain more than

| | | | |
|---|---|---|---|
| 2 | parts | organic carbon | in solution. |
| 0·3 | " | " nitrogen | |
| 3 | " | inorganic matter | in suspension. |
| 1 | " | organic matter | |

The Thames Conservancy Commissioners do not have quite so high a standard.

Precipitation :

The points to keep in mind are (*a*) the proportion of precipitants used, (*b*) the character of the precipitate likely to be obtained, and (*c*) its disposal ; (d) the character of the effluent.

The following are some of the principal processes :

The sewage is run into tanks, where it is allowed to purify by the subsidence of the matter in suspension, sometimes assisted by mechanical strainers ; but the effluent water is almost as dangerous as sewage itself, and requires purification before discharge into streams. It is usual to mix the fresh sewage before it runs into the settling tanks with chemicals, as lime, alum and iron, which may assist in the purification and perhaps disin-

* The Rivers' Pollution Prevention Act, 1876, requires that 'the best practicable and available means' are used to render the sewage matter harmless.

fection of the sewage ; but with most of them this is imperfectly done.

*Lime salts* are good precipitants, but have little effect on the organic matter ; the effluent soon becomes offensive. Fifteen grains of lime mixed with water (milk of lime), or 3 to 5 grains dissolved in water (lime water), are used for each gallon of sewage.

Whitthread's patent consists of lime combined with mono- and di-calcic phosphates. The deposit or sludge contains one-fourth of the matter in solution ; part of the ammonia and sulphides which are unstable. It has little value as a manure. The effluent contains much free ammonia, but is said to be of sufficient purity to discharge into streams.

*Aluminous substances* form gelatinous compounds which carry down a quantity of matter in suspension.

*Various patents :*

Bird's is aluminous earth with sulphuric acid.

Scott's, clay mixed with lime ; the sludge is burned afterwards to make cement.

Refuse of alum-works, with lime and charcoal.

Impure sulphate of alumina dissolved by sulphuric acid and mixed with lime (Anderson's or the Coventry process).

In all the above the quantity of substance used is about 5 grains each of lime and alum per gallon of sewer water.

The precipitate contains most of the solid matters with the phosphates, but not all the ammonia. When the sludge is pressed or dried it forms a valuable manure, especially for potatoes, and expense is small. The effluent is comparatively pure ; it contains more ammonia than the original sewer water, but less phosphoric acid, and one half the organic nitrogen (Voelcker's analysis). At Coventry the effluent water is filtered through land.

*A. B. C. process.*—To each gallon of sewage is added 30 to 70 grains ground clay, charcoal and blood ; at a later stage sulphate of alumina is run in. The theory is that the blood becomes coagulated by the action of the alum, and with the clay and bulky alum precipitate carry down all the suspended matters. The composition of the A. B. C. mixture varies.

Analyses show that while all suspended matters are thrown down, the sludge also contains much phosphoric acid and ammonia. The effluent, therefore, is purer than the standard, and at Aylesbury it goes straight to the river. The sludge when dried is sold as native guano, and appears to be a good manure. The process is a very expensive one.

*Black ash waste* (Hanson's patent) is the residue from the manufacture of washing-soda ; it should contain sulphites and hypo-sulphites of lime ; it has little precipitating power, but when mixed with a small proportion of lime it gives good results. It is in use at Aldershot and Leyton. The effluent is almost free from odour, contains little organic matter, and shows no liability to undergo putrefactive change, as many effluents soon do.

*Carbon* from various sources, peat, seaweed, etc. ; lignite, 'porous carbon' (lignite roasted with clay or iron, 4 grains to the gallon, Southampton) ; powdered coke with a little clay (Kingzett's patent) assists in the speedy separation of the solids, leaving an effluent suitable for irrigation. The sludge makes a fair manure, which breaks up better than sludges containing lime, or it may be converted into fuel for furnaces.

The process devised by Jagger and Furley seems to be cheap and useful. The dry ashpit refuse of towns is carbonized, and wire baskets are filled with the charcoal, the larger pieces at the bottom, the finer at the top ; the sewage then runs on to and through the baskets. The effluent is clear, inodorous and colourless, and may be discharged into streams. Little sludge is produced, as no chemicals are added to it, and it is pure manure.

One acre of filtering surface is sufficient for a population of 30,000 people.

*Iron.*—Various salts are used, but metallic precipitants are the most expensive. When iron rust with salt, and sulphuric acid are added to sewage, the peroxide of iron is precipitated and carries down suspended solids. Sulphides also are acted upon. The effluent soon putrefies. Sulphate of iron 1 grain with lime 4 grains per gallon is also used.

At Acton the system adopted is known as the *magnetic ferrous carbon* or *Ferozone process.* A mixture containing proto-sulphate of iron, alum and magnesia, with silica and magnetic oxide of iron, is added to the sewage. The sludge is small in quantity, contains much ammonia and phosphoric acid, all the suspended and 96 per cent. of the organic matter in solution, and forms a good forcing manure, recommended as a top dressing for grass, corn and roots. The effluent is further purified by being passed through magnetic spongy carbon or Polarite. One acre should purify 5,000,000 gallons of sewage effluent daily ; the process is rather costly

Other chemicals, such as salts or zinc, manganese and magnesia, have been used from time to time, but chiefly as deodorants ; but the quantities used are inadequate for the purpose.

*Aeration* has been advocated in order to produce oxidation and prevent putrefaction. The 'aquarium' or 'jet' system is the best of the various methods suggested. By this means air is introduced in a fine state of division instead of being in large bubbles, as in the 'blowing' system.

*Electricity* has lately been suggested by Mr. William Webster as a cheap and effective method of sewage purification. The sewage flows through a long channel, in which are a number of iron plates connected with a dynamo ; these become so many electrodes. It is claimed that suspended matters are precipitated with part of those in solution, while hypochlorous acid is produced and acts as an oxidiser. The effluent is clear and free from putrescible matter.

The *Amines* process : Herring brine contains ammonia compounds known as Amines. When these organic bases are added to milk of lime, the gaseous reagent (Amminol) is freely produced, and acts as a powerful disinfectant. When mixed with sewage, all micro-organisms are destroyed by it, and the solids are precipitated, and a clear effluent flows off. Although quite sterile, it has a strong smell, and contains dissolved organic matter and ammonia, and is best used on land. The sludge may be used as manure, or, when dried, to fill up low-lying lands.

*Disposal of sludge.*—In precipitation by chemicals the average weight of sludge per million gallons is 20 tons, and this contains about 90 per cent of moisture. The following are some of the plans adopted or recommended for its disposal :

(1) Spread on the ground and dug in (Birmingham) Suitable when the soil is gravel or sludge is small in amount.

(2) Mixed with road sweepings and ashes for manure (Southampton).

(3) Dried on hot floor or by steam, forming a powder; or made into cakes by patent presses (Leyton), and

(*a*) Used as manure.

(*b*) Made into cement or bricks; ought to be burnt first.

(*c*) Used to raise low-lying ground.

(*d*) Used as fuel for furnaces.

(*e*) Thrown into the sea.

*The effluent* in all cases contains some putrescible organic matter, as well as ammonia, potash and phosphoric acid, and when it is passed directly into a stream must increase the hardness of the water. It is desirable, therefore, that the process of separating the solids should be as simple and economical as possible, consistently with the prevention of nuisance. In most cases, then, the purification of the effluent by filtration through land is essential. This may be accomplished, on a small scale by *subsoil filtration.*

The system is carried out in this way: The whole of the household excreta, slops, etc., are allowed to flow into a Field's Automatic Flushing Tank, and at periodical intervals this flush tank discharges its contents into a drain which is impervious till it reaches the land in which it is to be utilized and purified; then pervious agricultural drains are laid, branching off the main at intervals, and the sewage percolates through into the soil. These drains are 2 inches in diameter, and ought to be laid at the depth of 1 foot. Before the sewage is allowed to enter the automatic flush tank, it ought to pass through a strainer so as to catch all solid material. This method does, of course, best in a porous loamy soil, and the land must be underdrained. There should be ventilation between the house and the drain. The agricultural drain must be taken up, cleansed and relaid every one or two years.

On a larger scale either *intermittent downward filtration* or *broad irrigation* must be employed.

The Royal Commissioners on Metropolitan sewage discharge have given the following definition of these terms: 'Broad irrigation means the distribution of sewage over a large surface of agricultural ground, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied': while in intermittent filtration 'the sewage is concentrated at short intervals, on an area of specially-chosen porous ground, as small as will absorb and cleanse it, not excluding vegetation, but making the produce of secondary importance. The intermittency of application is a *sine quâ non* even in suitably-constituted soils whenever complete success is aimed at.'

**Intermittent downward filtration** requires:

1. A porous soil, such as loose marl, containing oxide of iron and alum, sand or chalk ploughed in furrows.
2. An effluent drain about 6 feet from the surface.
3. A proper fall of land to allow the sewage to spread evenly.
4. The division of the area into four parts, each part to receive sewage for six hours, and to have an interval of eighteen hours.
5. The land thus used as a sewage filter requires constant aeration, not only by intermittent application, but also by being dug over or ploughed, else it will become 'sewage-sick'—*i.e.*, clogged up and oxidation stopped.

'*Nitrification*' is the process of oxidation of animal matter, which takes place in earth under the influence of living ferments. Ammonia, nitrites, nitrates and fatty hydrocarbons are the result. The presence of gypsum (calcium sulphate) appears to facilitate the process by providing a base. Although these organisms may exist to a depth of 6 feet, yet nitrification is carried out chiefly at the surface, and in the first 2 or 3 feet. Dr. P. Frankland has isolated one of these saprophytic organisms, which he has called a bacillo-coccus, from its shape. It appears to be the chief nitrifying agent.

The amount of land required varies with the nature of the soil. On an average, an acre will be sufficient for 1,000 people; but if precipitation or straining is practised first, an acre may do for from 3,000 to 5,000 of population. Crops should be grown on the land.

Average result of analysis shows that filtration removes 73 per cent. organic carbon, 87 per cent. organic nitrogen, and the whole of the suspended organic matter (P. F.

Frankland). The effluent is very pure, and gives rise to no after-nuisance when allowed to flow into streams. The process is successfully employed at Kendal and Merthyr Tydvil and elsewhere.

**Irrigation** is another and more important form by which sewage may be applied to land, and is the one most commonly used. The sewer-water, in as fresh a state as possible after being strained or precipitated, is distributed over the surface of cultivated land, with a view of bringing it as speedily as possible under the influence of growing plants, the purified liquid being carried off by natural or artificial drains.

The 'sewage-farm' should be on a gentle slope, and be intersected with trenches provided with dams, so that the water may be distributed as required. If a slope cannot be had, then artificial slopes must be constructed with a trench along the summit. The sewer-water should flow at the rate of 8 feet per hour. In winter the flow may be constant, so as to store up nourishment for plant-growth in spring, but when the plants are growing the flow is intermittent.

'Arrosage' is the term used when the sewage flows along furrows, not wetting the vegetables planted thereon.

'Colmatage' means that the whole surface is submerged.

The former is practised at Paris in summer, the latter in winter.

Land required.—On an average an acre should be allowed for 100 persons; not more than £2 10s. per acre should be paid for rent (Bailey Denton). The site should be of easy access; there should be land available in case of increase of population, and an outlet for the sale of produce.

*Results:*

- Suspended matters are arrested.
- Nitrification occurs.
- Chemical interchanges take place, thus phosphoric acid joins with hydrated ferric oxide and alumina.
- Ammonia and potassium silicates with aluminum are formed by displacing calcium, which becomes a carbonate. These bases also form insoluble compounds with humus.

If the sewage be not strained first, and under-draining not adopted so that the effluent does not pass through the soil, but only over it, then the effluent will not be so pure as in downward filtration, which has advantage over irrigation, in that whereas a smaller area of land is exposed, the danger to subsoil waters is diminished by careful under-drainage. But when sewage-farms are well managed and properly under-drained, so that filtration through it occurs, no nuisance should be created, nor should the ground become swampy, and it has not yet been shown that entozoic disease is more prevalent with this plan than with any other method.

Crops.—Italian rye-grass, osiers and roots, as mangel-wurzels, can be grown most successfully : under certain circumstances market vegetables may also be planted ; cattle may be allowed with safety to graze on a sewage-farm. When the rainfall has been excessive, the sewage-water will be too dilute to apply to the land, so must be passed on to the river or sea without purification, unless a small part of the farm be reserved as a closely-drained filter for this purpose. Here the advantage of the 'separate' system is manifest.

When land is available, and waste-land can be utilized for the purpose, there is no doubt that it is the proper destination for the sewage, as well as being the most efficient method of purification we possess.

### 2. Dry Methods.

The use of cesspools, privy pits, dead-wells, etc., should be discontinued. If excreta are ever allowed to accumulate, it should be in properly-constructed non-porous receptacles, and after admixture with deodorants. In No. 1 of the model bye-laws, instructions are laid down as to how these places, when permitted, must be dealt with in order to minimize the danger to health. When filth is removed from privies, etc., sulphate of iron in strong solution or in powder (when the filth is wet or semi-solid) should be well mixed with successive layers of the matter to be removed ; but it would be much better if the filth could be emptied by pneumatic pressure, as in Paris.

All the dry methods (sometimes called 'conservancy system') requires some arrangement to carry off rain-water, slop-water, etc. For small places, 'sub-irrigation' already mentioned may be adopted; larger places must have a proper scheme of sewerage.

The *pail* system.—In the poorer parts of many towns this system is in use. Each family is provided with a pail, having a close-fitting lid; into this all excreta, and generally other refuse, are placed. The pails must be emptied daily. Sometimes the pails are lined with cloth refuse (Salford, etc.), or with straw, etc. (Goux' patent), the fæcal matter is thus rendered drier by the absorption of the urine, and decomposition is delayed. Other plans include the addition of various materials to the excreta, thus:

*Dried earth.*—The best kind is clay (silicates of alumina), marl, and vegetable mould, 1½ lb. is required for each dejection. The excreta are deodorized, and organic matters disintegrated. If the urine goes with fæces a larger amount of earth must be used; modifications have therefore been made in special closets (Moule's, etc.), to carry off the urine.

In India a simpler plan is followed, shallow trenches are dug in a field, and earth thrown over the excreta; when the trenches are full the whole is ploughed up, and vegetables at once planted: two or three crops are taken before that ground is again used.

Coal and wood ashes may be used alone or with earth.

*Charcoal* may be cheaply used in the shape of peat or sea-weed charcoal: 3 ounces equals 1½ lb. of earth. Both fæces and urine may pass into same receptacle: the mixture can be recarbonized in a retort, and the carbon used again, while noxious agencies are destroyed; the distilled products (ammoniacal liquor, containing acetate of lime, tar, etc.) which result, are sufficient to pay the cost.

*Soot and salt* (Nicholl's) mixture is a satisfactory substitute for earth.

*Deodorant powders.*—Instead of earth and charcoal, powders and sawdust, containing various disinfectants, are in use. These are too expensive for ordinary use.

*Position of the closet.*—It should never be in a basement: best in detached building, with thorough ventilation between it and house: both receptacle and closet should be ventilated to outer air.

*Disposal of the contents of the receptacles.*—They may be at once applied to land as manure at some distance from dwellings. When this cannot be done, they may be dried and converted into manure as a powder ; or they may be carbonized, or burnt.

*Liernur's Pneumatic Air plan* is employed in Holland : the excreta fall into a pipe from which they are extracted by exhaustion of the air by an air-pump. The pipes are never clean, but become lined with decomposing fæces. A separate arrangement is required for rain and slop water.

**Choice of method for disposal of excreta.**—This depends entirely upon the circumstances of the locality. For large communities the water-sewage plan (with or without interception of rainfall) appears best suited ; while for villages and small towns this would be too expensive ; or again, where a fall cannot be obtained, or water is insufficient, the water system could not be used.

## CLEANSING OF TOWNS.

*Disposal of house-refuse.*—The old system of dust-bins, ash-pits, or middens is gradually giving place to one in which the house-refuse is daily removed from pails. Householders ought to burn vegetable matters themselves.

The practice of levelling up low-lying land, brickfields, old quarries, etc., with the refuse is not to be recommended unless the material has been burnt.

At Rochdale the ashes and excreta are mixed and dried, and used as manure.

At Manchester the coarser part of the rubbish and the cinders are burnt under boilers, etc., the clinkers resulting are ground into powder, and used for making mortar.

Soap and oil are extracted from bodies of dead animals.

At Leeds, Ealing, Whitechapel, and elsewhere, there was considerable difficulty in getting rid of the refuse, either on land or in the sea ; recourse has, therefore, been had to carbonizing or to burning it in 'Destructors,' which, with care in stoking and cleansing, can be used without causing nuisance. Offensive smells are prevented by the use of an additional furnace called a 'fume cremator,' which destroys all gases passing from the destructor.

Charred paper and dust sometimes escape, and settle in the vicinity of the works. To remedy this the main flue is enlarged, and low walls built across it at intervals to intercept the dust, while wire screens will prevent the escape of charred paper ; the fine dust obtained from the flues has been mixed with carbolic acid, and made into disinfecting powder.

Street-sweepings may be utilized as manure, or burnt in the destructor. When very liquid, the excessive moisture should be allowed to drain off first. When the contents of street-gullies are removed, they should be well covered over with some disinfecting powder.

Courts, alleys, urinals, etc., should be properly paved with some impervious material, so that they can be washed with the hose regularly and frequently.

For street-watering, sea-water may be used, as at Hastings, Portsmouth, etc. It binds the surface of the roads, and they require a third less frequent watering, as they remain damp longer than with fresh water. In the more crowded districts of a town, or when an epidemic has broken out, the addition of 'Sanitas' to the water is beneficial and refreshing.

After falls of snow, gutters and gullies should be cleared, else flooding of houses might ensue if a thaw set in.

## CHAPTER IV.

### AIR AND VENTILATION

### Air.

*The Average Composition of Atmospheric Air is:*

Oxygen—209·6 per 1,000 volumes.
Nitrogen—790·0 per 1,000 volumes.
Carbonic acid (carbon dioxide)—0·4 per 1,000 volumes.
Watery vapour — varies with temperature from 1 to 12 grains per cubic foot of air.
Ammonia—traces.

Organic matter (in vapour or suspended, organized or unorganized, dead or living)—traces.
Ozone—variable.
Sodium and other mineral salts—variable.

The above table gives the average composition, but the oxygen may reach 209·8 in pure mountain air, or fall to 208·7 in towns. By weight 23 per cent. is oxygen.

*Impurities.*—The carbonic dioxide and other impurities are derived from the products of respiration, combustion, manufactures, the decomposition of organic matters, etc. The air is, however, kept in a state of purity by natural processes, mechanical and chemical. Of these the chief are diffusion, dilution by winds, oxidation, the fall of rain washing down and dissolving both gases and solids, and the influence of plant-life.

*The suspended matters are:* Silica, silicate of alumina, carbonate and phosphate of calcium, and peroxide of iron from the soil, carbon, sand and fine mud from volcanoes.

Seeds and débris of vegetation; pollen; spores of fungi, mycoderms, mucedines; germs of vibriones, monads, and other micro-organisms; various forms of minute animal life, alive and dead.

Chloride of sodium derived from the sea in spray.

Dried excreta, etc., of man and animals.

In inhabited rooms there may be found epithelium, fibres of clothing; portions of food; hair, wood, coal, arsenic (from wall-papers); while in sick rooms organic matter is in large quantity with epithelium and pus-cells, bacilli and fungi.

In workshops, factories, and mines, dust from the fabrics and materials pass into the air.

*The gaseous impurities are:* Carbon dioxide, carbon monoxide, carburetted hydrogen or methane, and organic substances (gaseous) in sewer air.

Sulphur dioxide, sulphuric acid, hydrogen and ammonium sulphide, and carbon disulphide.

Hydrochloric acid (from alkali works).

Ammonia; ammonium acetate, sulphide and carbonate; nitrous and nitric acids.

Hydrogen phosphide.

Organic vapours from decomposing animal matters.

*Respiration* is responsible for the following: Oxygen is decreased; carbonic dioxide is increased; watery vapour with ammonia and organic matters is produced.

*Carbonic dioxide.*—An adult man, weighing 12 stone, in a state of repose will give off about 0·72 cubic feet per hour, mostly from the lungs, but partly from the skin. This amount varies proportionately with the body weight. Women, children, and old people, give off less $CO_2$. The amount is increased by exertion in this proportion: In repose, 2; in gentle exercise, 3; in hard work, 6 (Pettenkofer).

Average amount of $CO_2$ per hour per person in a mixed community is 0·6 of a cubic foot, equal to about 8 oz. of carbon in twenty-four hours.

Expired air contains oxygen 169·6, nitrogen 790, and carbonic acid 40·4 parts per 1,000.

Amount of air daily taken into the lungs by a man is estimated at 400 cubic feet, 30 cubic inches per respiration.

*Moisture with organic matter.*—Twenty-five to forty oz. of water pass off daily by the skin and lungs, requiring on an average 211 cubic feet of air per hour to maintain it in a state of vapour.

The *organic matter* is the most important impurity resulting from respiration; it consists partly of suspended matter, epithelium, etc., and partly of fœtid substances containing ammonia and sulphur in their composition. It is slowly oxidizable. When drawn through sulphuric acid it darkens it; permanganate of potash solution is decolourized by it. When collected from the air, nitrate of silver causes a precipitate, and it blackens on platinum.

It has a great affinity for water, and is readily absorbed by damp walls. It is deposited on furniture and clothing —straw and horse-hair absorbing least, white and yellow bodies taking less than black and blue.

It is this which gives the feeling of closeness to ill-ventilated rooms. The amount of organic matter is in proportion to the $CO_2$ present; thus when $CO_2$ reaches 0·6 per 1,000 volumes, the organic matter can readily be detected by the sense of smell.

*Combustion.* — The air within dwellings is chiefly affected by the products of lighting. *Coal*, when burnt, yields:

| | |
|---|---|
| Water<br>Fine carbon, and<br>Tarry particles | 1 per cent. of its weight. |
| Carbon dioxide...... | about 3 tons for each ton of coal. |
| Carbon monoxide | depends on the perfection of combustion. Usually a small quantity; larger with anthracite coal. |
| Sulphur, sulphur dioxide, and sulphuric acid | coal contains ½ to 7 per cent. |
| Carbon disulphide<br>Ammonium sulphide or carbonate<br>Hydrogen sulphide (sometimes) | Chiefly from certain kinds of factories. |

For complete combustion, 1 lb. of coal requires about 240 cubic feet of air.

*Coal gas* has an average composition of :

| | In 100 parts. |
|---|---|
| Hydrogen ... ... ... ... ... | 42 |
| Light carburetted hydrogen ($CH_4$) ... | 38 |
| Carbon monoxide ... ... ... ... | 4·5 |
| Olefiant gas (ethylene, $C_2H_4$) ... ... | 3·5 |
| Acetylene (ethine, $C_2H_2$) ... ... ... | 2·5 |
| Hydrogen sulphide ... ... ... | 0·5 |
| Nitrogen ... ... ... ... ... | 2 |
| Carbon dioxide ... ... ... ... | 3 |
| Sulphur dioxide ... ... ... ... | 0·5 |
| Ammonium sulphide ... ... ... | traces |
| Carbon disulphide ... ... ... ... | traces |

Gas is purified before leaving the works by washing to remove tar ; it is then dried and passed over lime or sesquioxide of iron to take away hydrogen and ammonium sulphides, etc. If this be not done thoroughly, these impurities will be passed into the air of the rooms in which the gas is used.

The value of coal gas as regards its illuminating power is ascertained by comparing the light given off by gas burning at the rate of 5 cubic feet per hour with that of a sperm candle burning 120 grains per hour. Thus cannel-coal gas is said to be equal to 34·4 candles, and gas from common coal to 13 candles (Roscoe).

Sulphur, according to Act of Parliament, must not exceed 20 grains per 100 cubic feet.

In ordinary combustion, the following products escape into the air :

| | |
|---|---|
| Nitrogen ... ... ... ... | 67 per cent. |
| Water ... ... ... ... | 16 " |
| Carbon dioxide ... ... ... | 7 " |
| Sulphur dioxide ... ... ... | small quantities. |
| Ammonia ... ... ... ... | " |

Carbon monoxide, 5 per cent.; but with perfect combustion, none.

One cubic foot of gas unites with from 0·9 to 1·64 cubic feet of oxygen (8 cubic feet of air), producing 2 cubic feet of carbon dioxide, and from 0·2 to 0·5 grains of sulphur dioxide. Various plans are adopted to render the combustions more perfect, as by the Argand and Siemens burners ; the use of the Welsbach incandescent burner; by the addition of Naphthaline (albo-carbon), and by the use of regulators on the pipes so that the pressure may be constant.

One cubic foot of gas will raise the temperature of 31,290 cubic feet of air 1° F.

*Wood* produces carbon dioxide and monoxide and water, and requires about 120 cubic feet of air for the complete combustion of 1 lb.

*Oil.*—One pound requires 140 to 160 cubic feet of air for complete combustion ; 150 grains of oil or 170 grains of candle are burnt per hour, consuming the oxygen of about 3·2 cubic feet of air, and producing about ½ cubic foot of $CO_2$.

*Tobacco smoke* contains much carbon dioxide, ammonia, and butyric acid, with salts of nicotine, and probably of picoline. In smoking-cars Dr. Ripley Nichols found four or five times more ammonia than in external air.

*Water gas.*—This gas is produced by passing steam through coals at a red heat ; and the consequence is that after purification hydrogen only remains. This mixture is very inflammable, and while burning gives out a very great heat, but it is not capable by itself of yielding much luminosity. It can be used for heating and cooking, and would be suitable for use with incandescent burners. On combustion, watery vapour only is formed. In the process of manufacture, carbon monoxide is produced, and precautions must be taken to prevent the workmen inhaling it.

*Effects produced by the Products of Combustion passing into the Air.*

Carbon dioxide soon becomes diffused.

Suspended carbon and tarry matters, as a rule, are not found at a higher altitude than 600 feet. Smoke from houses, even in large towns, does not appear to affect the atmosphere so much as that given off by factories, foundries, etc. Compare the condition in this respect of Lancashire manufacturing towns with non-manufacturing towns, or West with East London. The organic matter in the air is increased by the combustion of coal and by oil lamps. But the most noxious contaminations derived from coal are the hydrochloric, sulphurous and sulphuric acids, which in many manufacturing towns render the air distinctly acid. (Angus Smith, Fletcher and others.) To the presence of these acids is ascribed the deleterious influence of coal smoke upon vegetation.

*Smoke abatement.* — By the Health Act, 1875, the emission of black smoke from a factory chimney is declared to be a nuisance, and may be suppressed ; but as the administration of the Act is left to local authorities, they often, from personal motives, allow the clause to become a dead letter. In London, however, the administration of the Smoke Acts (1853 and 1856) is vested in the Commissioners of Police, and, as results show, with more success than has been obtained in the provinces.

In order to prevent black smoke from furnaces, Mr. Alfred E. Fletcher points out that three conditions must be observed :

(1) There must be a sufficiency of air.

(2) The air must be well mixed with the gases.

(3) This mixture must be raised to the temperature necessary for ignition.

Besides the numerous contrivances for carrying out these conditions, there have been invented mechanical stokers, whereby the fuel is regularly and continuously supplied. In the Hopcraft furnace the coal, which may be common slack, is stoked automatically from below, so that no smoke results.

Various other patents have the same aim, such as Ashworth and Keen's furnace, Hargreave's hot-air engine, etc.

By the use of Johnson's smoke-washer the whole of the acids, together with the carbon and tarry matters and any other noxious fumes, are completely removed from the smoke at a small expense.

Smoke from private houses.—Numerous plans have been suggested, such as the use of gas and of water-gas slow combustion stoves, heating by means of hot air, the use of 'smokeless' (anthracite) coal, and various contrivances in open grates (Siemens, Teale, etc.).

Frankland recommends throttling the chimney-mouth, and the use of coke broken small.

### *Diseases produced by Impurities in the Air.*

(1) *By suspended solid matters.*—Under this head are included diseases due to :

(*a*) Various unhealthy occupations.
(*b*) Living substances, as fungi, algæ, pollen, etc.
(*c*) The contagia.

(*a*) *Unhealthy occupations* affect the health chiefly by means of *dust*, but the whole subject may be conveniently noticed here. Dr. Arlidge, in the Milroy Lectures (1889, 'Occupations and Trade in relation to Public Health'), has divided the conditions causative of disease thus :

(1) Generation of dust { Poisonous. / Non-poisonous. / With heat and moisture.
(2) Employment of materials of a distinctly poisonous or highly noxious nature.
(3) Evolution of poisonous or injurious vapour.
(4) Excessive temperature.
(5) Evolution of electricity.
(6) Abnormal atmospheric pressure.
(7) Circumstances affecting special senses.
(8) Excessive use, friction or strain on parts of the body.
(9) Exposure to infectious, contagious or parasitic diseases.
(10) Extra liability to accidents.

Besides, there are the more general conditions of situation and construction of factory, etc.; the soil, climate, population, etc.

*Dust* produces respiratory diseases such as frequently recurring catarrhs (with or without expectoration), bronchitis, followed sometimes by emphysema. Acute pneumonia, asthma, and chronic non-tubercular phthisis, as well as, in many instances, tubercular disease of the lungs. This is well shown by Dr. Ogle in his supplement to the forty-fifth Annual Report of the Registrar-General, where he gives the table printed on p. 74.

The digestive organs are affected only to a slight extent.

The suspended matters may be mineral, vegetable, or animal. According to Parkes the severity of the effects is chiefly dependent on the amount of dust and on the physical conditions as to angularity, roughness or smooth ness of the particles, and not on the nature of the substances, except in some special cases; while Dr. Arlidge states that earthy and metallic dusts are more provocative of lung disablement than organic dust, with the exception of charcoal; but then it is inorganic dusts and charcoal that possess those physical characters which tend to produce the more severe effects.

*Miners* of all kinds suffer from an excess of pulmonary disease caused by the inhalation of dust which is produced by their work; but coal-miners suffer less in this respect than other workers in mines. The air of mines is rendered impure also by respiration, combustion from lights and from blasting operations, and from the escape of fire-damp ($CH_4$) and carbonic dioxide from cavities in the rocks. When gunpowder is used, carbon dioxide and monoxide, hydrogen and hydrogen sulphide are added to the air, with suspended particles of potassium sulphate, carbonate hyposulphite, sulphide, sulphocyanide and nitrate, carbon, sulphur and ammonia carbonate. Dynamite and gun-cotton add nitrous fumes to the air, but no carbon monoxide or hydrogen sulphide; the use of roburite (chloro-dinitro benzol and nitrate of ammonia) seems likely to take the place of other agents for shot-firing in mines, as carbon dioxide to a small amount is the chief impurity, and there is an absence of smoke.

Prevention of disease arising in connection with mines depends in a great measure upon the thoroughness of the

*Comparative Mortality of Males, twenty-five to sixty-five years of age, in certain Dust-inhaling Occupations, from Phthisis and Diseases of the Respiratory Organs.*

| Occupation. | Phthisis. | Diseases of the Respiratory Organs. | Phthisis and Diseases of the Respiratory Organs. |
|---|---|---|---|
| Coal-miner ... ... ... ... ... ... | 126 | 202 | 328 |
| Carpenter, joiner ... ... ... ... ... | 204 | 133 | 337 |
| Baker, confectioner ... ... ... ... | 212 | 186 | 398 |
| Plumber, painter, glazier... ... ... ... | 246 | 185 | 431 |
| Mason, builder, bricklayer ... ... ... | 252 | 201 | 453 |
| Wool manufacturer ... ... ... ... | 257 | 205 | 462 |
| Cotton manufacturer ... ... .. ... | 272 | 271 | 543 |
| Quarry-man (stone, slate) ... ... ... | 308 | 274 | 582 |
| Cutler ... ... ... ... ... ... | 371 | 389 | 760 |
| File-maker ... ... ... ... ... ... | 433 | 350 | 783 |
| Earthenware manufacturer ... ... ... | 473 | 645 | 1,118 |
| Cornish miner (tin) ... ... ... ... | 690 | 458 | 1,148 |
| All males (England and Wales) ... ... ... | 220 | 182 | 340 |
| Fishermen ... ... ... ... ... ... | 108 | 90 | 198 |

ventilation. As better ventilation has been introduced into collieries, the 'coal-miner's lung' has become a less frequently seen pathological specimen. The following list includes most of the trades which affect workmen injuriously by means of dust :

Corn-millers and bakers, maltsters, teamen, coffee-roasters, snuff-makers, paper-makers, flock-dressers, shoddy-grinders, coverlet and harding weavers, dressers of hair, of coloured leather, of hemp ; workers in flax, cotton, wool and silk, some workers in wood, wire-grinders, masons, colliers, iron-miners, lead-miners, grinders of metals (especially of the finer tools), file-cutters, firearm-makers, button (especially mother-of-pearl) makers, potters, china-scourers, electro-plate-workers, grinding stone, sandpaper and glass makers ; cement and poudrette makers, workers with arsenic and lead, drug and colour grinders and mixers, etc.

In all of these trades good ventilation and personal cleanliness diminish the evil to a great extent, but additional contrivances have been suggested to suit the varied requirements of the different kinds of labour ; thus, wet-grinding, ventilated wheel-boxes, and the wearing of coverings for the mouth and nose, such as Loeb's respirator, may be employed. This form of respirator enables the wearer to breathe comfortably in an atmosphere full of dust, noxious gases or dense smoke.

In the manufacture of super-phosphates, in addition to the dust, there is danger from the vapour of silicon fluoride, which causes a gelatinous deposit on the mucous membrane of the air passages, producing suffocation (C. A. Cameron).

*Bichromate of potash* dust causes irritation, ulceration and destruction of both the mucous membrane and bones of nose. The taking of snuff prevents these results by removing the particles from the nose. The fluids of the mouth dissolve, and get rid of the salt, but the skin is apt to have sores produced unless washed with subacetate of lead.

*Wood-dusts* act as irritants in proportion to their density—ebony and rosewood dusts produce bronchial troubles, and it is said the latter may cause eczema.

Of *textile* manufactures, that of *flax* produces more dyspnœa than is caused by any other dust not actually poisonous.

When the best *silk* is used disease is not caused, but follows on the preparation for trade purposes of inferior silk and silk waste; in the 'gassing-rooms' the air is rendered additionally impure from the gas and from the scorching of the silk particles; the temperature is high—90° to 120° F. The use of Bunsen burners would be an improvement.

Pure *wool* is little less healthy than silk in its manufacture, but in the cleansing stage there is a liability to acquire wool-sorters' disease by sorters, washers, packers, carders, combers, over-lookers, buyers and staplers.

'Shoddy-disease'—headache, sickness, dryness of mouth, difficulty of breathing, cough and expectoration (Greenhow)—sometimes results in those attending the tearing up and grinding of old woollen materials.

Wool extracting from mixed tissues by muriatic acid produces a dust of finely divided particles of carbon, which sometimes explode.

In connection with the *cotton* trade there is dust of various kinds present in the different processes, and its removal is rendered difficult, as the cotton is very susceptible to variations in the atmospheres of the rooms. Inlet tubes and fans, extracting the air and dust by suction, are generally used.

Cotton weaving.—During the American Civil War, when cotton was scarce, manufacturers resorted to the expedient of sizing the yarn to bring the fabric up to the required weight, and have not since given up the practice. Sized goods are in demand in warm countries, where their stiffness appears to be appreciated. The difficulty is to keep the sizing (which consists of tallow, flour, china clay) on the yarn while it is being woven; this has been overcome by allowing steam to escape over the workpeople's heads, so as to keep the fabric moist. The atmosphere is further vitiated by the use of gas in winter. The operatives, who are mostly women and children, get their clothing saturated with the moisture, and on going out of the hot rooms are liable to rheumatism, bronchitis, etc. An escape for air is usually provided near the ridge of each roof, but this gets blocked up in winter, and is rarely reopened. As only a small quantity of steam is required, it might be possible to have its admission, etc., regulated in such a manner as would not be injurious to health, such as introducing the steam immediately below the weft; while the use of the electric light might advantageously supersede gas.

Chimney-sweeps used to suffer from cancer due to the irritation of the soot, but this is not so common now that climbing up the chimneys has been done away with. Workers in petroleum and tar are said to be similarly affected.

Match-makers who are exposed to the fumes of white *phosphorus* suffer from necrosis of the jaw. This may be obviated by the use of red amorphous phosphorus.

*Brass* founders suffer from 'brass founders' ague,' characterized by feelings of tightness and oppression of the chest, with shiverings, headache, nausea and muscular pains, an indistinct hot stage and profuse sweating. The attacks are not periodical, but are more frequent in foggy weather and in ill-ventilated shops. The workmen are also subject to various nervous disorders. There is a difference of opinion as to the cause; some assert it to be due to the fumes of zinc oxide, but it is more probably due to copper poisoning, as copper-smiths are similarly affected. A green line is generally to be seen on the teeth of the lower jaw. Large draughts of milk are believed to lessen the severity of the attacks.

Plumbers, house-painters and white-lead manufacturers inhale the dust and suffer from *lead*-poisoning, characterized by tightness at the chest, nausea, twisting pain at umbilicus, anæmia, weakness and trembling of the muscles of arm, especially of the extensors of the wrist and fingers, neuralgic pains often in muscles, epilepsy, weakness of intellect, etc. There is a blue line on the edge of the gums due to sulphide of lead.

Prevention.—Cleanliness; workmen not to eat food in the workshops: frequent washing of hands and clothes; the use of drinks containing sulphuric acid. The adoption of moist instead of dry processes in the manufacture of white lead.

Workers in *mercury*, mirror silverers, etc., may get salivated with general cachexia, headache, numbness and unsteadiness, beginning in hands and arms and spreading to the rest of the system.

Preventive measures.—Work to be done in well-ventilated rooms; cleanliness; not to eat in workrooms. Mirrors can be made with nitrate of silver.

*Arsenical* poisoning may result in those who use compounds of arsenic, as in the making of wall-papers, artificial flowers, or who have inhaled the dust of rooms papered with arsenical papers. The effects are both local and constitutional, the local being smarting of the gums, eyes, nose, œdema of the eyelids, and little ulcers on exposed parts of the body; the constitutional being weakness, faintness, asthma, anorexia, thirst, diarrhœa, and sometimes severe nervous symptoms. In bone manure factories it has been shown that arsenic is given off in considerable quantity; this is due to the use of impure sulphuric acid. This also occurs in copper smelting.

*Diseases produced by Living Substances, or their Germs or Pollen of Flowers.*

Hay fever or summer catarrh by the pollen from grasses (especially anthoxanthum odoratum), trees (especially lime) or flowers. Nausea, fainting and giddiness are produced by chætonium elatum (bristle mould), and the spore of penicillium when inhaled has produced hoarseness and aphonia with catarrh.

Tinea and favus may be spread by air.

The examination of air has been carried out for some years very methodically by Dr. Miguel at the observatory of Montsouris in Paris. He found that fungoid spores were more plentiful in the air in hot weather than in cold. Bacteria of various kinds were always present in Paris; at an altitude of from 2,000 to 4,000 mètres on the Alps no microbes were found; as he descended the number gradually increased until 760 microbes per cubic mètre were found in the park at Montsouris, and 5,500 in the Rue de Rivoli. In hospitals, Miguel reports that in winter, when the windows are kept shut, the greatest number of microbes is to be found, which is the reverse of the condition obtaining in the open air.

In this country the presence of microbes in houses, schools, etc., has been demonstrated by Carnelly and others; and they have shown the improvement that can be produced by proper ventilation. In houses the number of microbes increases in proportion as the living rooms decrease in size, and according to how many rooms constitute a house; thus, a one-roomed house contains more microbes than a two-roomed house; and sickness and mortality go *pari passu*.

That the following diseases reach the person through the medium of the air cannot be doubted, viz., scarlet-fever, small-pox, measles, typhus, enteric fever, plague, pertussis, yellow fever, diphtheria, influenza, purulent and granular ophthalmia, erysipelas, hospital gangrene; perhaps also cholera. Most probably the disease poisons are living organisms or their spores, which exist separately or in epithelium, pus cells, or other disintegrating organic material (see article on the Contagia).

*Diseases produced by Gaseous Matters in the Air.*

*Carbon dioxide* produces fatal results when the amount reaches from 50 to 100 parts per 1,000: 15 to 20 per 1,000 produces headache in some, but this is probably due to organic matter, though well-sinkers are sometimes affected with headache, sickness and loss of appetite; living continuously in an atmosphere heavily charged with $CO_2$ may, by preventing its elimination from the blood, produce serious alterations in nutrition. Angus Smith states that when the quantity of $CO_2$ was increased that the heart's action was slowed with quickened respiration, but he is not confirmed by other experimenters with pure $CO_2$.

Acute poisoning causes sudden loss of consciousness, the blood becomes of a dark hue; a person so affected by $CO_2$ should be immediately removed to purer air.

*Carbon monoxide* (CO).—Less than a half per cent. has produced symptoms of poisoning, one per cent. is fatal. Poisoning thereby is characterized by unconsciousness, destruction of reflex action, atony of vessels, diminution of vascular pressure, slowness of circulation, and finally, paralysis of the heart. At high temperatures there may be convulsions. The blood is of a florid red colour (more of a chocolate red than ordinary arterial blood), due to the formation of a compound of CO and hæmoglobin. Fresh air does no good, as the oxygen cannot displace the CO from the compound; it is possible that the CO may be converted into $CO_2$, and so be got rid of; but transfusion is the best treatment; CO is evolved from iron and copper furnaces, and with $CO_2$ and $H_2S$ from brickfields and cement works.

*Hydrogen sulphide* ($H_2S$).—Men who are exposed to large quantities of sulphuretted hydrogen suffer from weakness, anorexia, slow pulse, furred tongue, face and mucous membrane pale; sometimes there are boils on the body, sometimes vertigo, headache, nausea, diarrhœa. Great differences of susceptibility; some are quite unaffected.

Acute poisoning also occurs either in a narcotic or in a convulsive form.

Dogs and horses are more affected than are men.

Hydrogen sulphide is evolved in chemical works (especially ammonia); Britannia metal works; in tunnels and mines (from the decomposition of iron pyrites).

*Ammoniacal vapours* produce irritation of the mucous surfaces with which they come in contact—the conjunctiva suffers most.

*Sulphur dioxide* ($SO_2$) is evolved in copper-smelting works, and in the bleaching operations in cotton and worsted factories. It produces anæmia and bronchitis if in any amount. When washed down by the rain it affects cattle through the herbage, producing affection of the bone, falling off of the hair and emaciation.

*Hydrochloric acid vapours* in large quantities are very irritating to the lungs; and they destroy vegetation even when diluted to one-fifth grain in each cubic foot of air gas or smoke escaping into the atmosphere (as they now are in alkali works).* In some processes for making steel, hydrochloric, sulphurous and nitrous acids are all given out, and cause eye diseases, bronchitis, pneumonia, destruction of lung tissue.

*Carbon disulphide* is given out in the manufacture of vulcanized indiarubber, and produces headache, giddiness, pains in the limbs, nervous depression, and insomnia; sometimes also deafness, dyspnœa, cough, febrile attacks, amaurosis and paraplegia (Delpech). The nervous system seems to be affected by it.

*Effects of Air impure from several Substances always co-existing.*

*Air rendered impure by respiration.*—When the air is very impure, death ensues from the deficiency of oxygen and

* *Vide* the Alkali, etc., Works' Regulation Act of 1881 (it consolidates the Acts of 1863 and 1874).

from the presence of poisonous *organic matter*, as in the notorious Black Hole of Calcutta ; if, after inhaling it, immediate death does not ensue, then a febrile condition, with boils and other evidences of impaired nutrition, is produced, and may ultimately prove fatal.

When the air is not so impure, heaviness, headache, inertness, and nausea are produced ; living continuously in a vitiated atmosphere, as in overcrowded houses or districts, produces anæmia, loss of appetite and strength from the defective aëration and nutrition of the blood. Such a condition very strongly predisposes to diseases of the respiratory organs, and especially to phthisis ; and assists in the more rapid spread of several specific diseases, especially typhus exanthematicus, plague, small-pox, scarlet-fever, and measles.

*Air rendered impure by exhalations from the sick.*—Severity of many diseases, especially the febrile, is increased and convalescence prolonged. At a certain point of impurity erysipelas and hospital gangrene appear.

*Air rendered impure by combustion.*—Theoretically it may be that carbon and sulphur dioxide act as disinfectants to a certain extent, but practically infectious diseases are not less common in colliery districts or in smoky towns, while bronchitis is certainly due to the irritation of the respiratory passages. Statistics show an increase in the mortality from lung diseases during foggy weather.

The effects of breathing the products of combustion, especially of gas, are headache, heaviness, and oppression ; breathed continuously, or for long periods, as in dark workshops, etc., anæmia and general want of tone are produced. Gas escaping in small quantities into bedrooms will produce a form of sore throat.

*Air rendered impure by the gas and effluvia from sewers and house drains.*—When sewers are well laid, well ventilated, and not blocked, the men employed in them do not appear to suffer from any special liability to any disease ; but if the sewers be blocked, and often in house drains and in cesspools, the air becomes extremely offensive, and the breathing of this air (containing hydrogen and ammonium sulphides, carbon dioxide, nitrogen, and organic vapours) has produced vomiting and purging headache, great prostration, and convulsive twitchings of the muscles, and even asphyxia.

If sewers are partially ventilated, with $CO_2$ in excess, moulds will grow rather than bacteria. They help to purify the air and water.

The continual escape of sewer air into houses, and especially into the bedrooms, causes an impaired state of health, especially in children, who lose appetite, become anæmic and languid ; have diarrhœa, headaches, feverishness, sore throat, the fauces and tonsils being of a dull purple red colour. Older persons suffer from headache, malaise, feverishness, and sore throat. It also aggravates the severity of all the exanthemata, and has probably an injurious effect on all diseases, especially those of the digestive system.

Enteric fever and diphtheria have been known to arise from the air of sewers, and have been communicated to persons congregating over ventilating gratings, etc., but only if the specific causes are present in the sewer. Dr. Buchanan has pointed out that the purification of the air by sewerage and cleanliness has been most uniformly followed up by a fall in the prevalence of typhoid. It has been suggested that the permanent raising of the temperature in sewers by the discharge of hot water may change benign bacteria into malignant ; but these risks should be minimized if the sewers are well and truly laid, the pipes smooth inside and properly jointed ; if they flush clean and are properly flushed at intervals depending on the temperature of the sewage (Carpenter).

No harm seems to follow the application of fresh sewage to the ground, but if decomposition has fully set in, the deodorizing and absorbing powers of the earth may be overtaxed, and disease might be caused ; as also with improperly-managed sewage-farms.

*Emanations from streams polluted by fæcal matter.*—Evidence as to disease from this cause is conflicting, due to the varying dilution of fæcal matter, and to the presence or absence of tides, since on the going out of the tide, masses of decaying matter would be left on the banks ; the same danger is caused when sewage is washed back by the sea, or when rivers dry up considerably in hot weather. Where such conditions obtain the general health of the people living near must suffer, and should there be present germs of any specific disease, as enteric fever, that disease may be developed.

*Manure factories* do not appear to affect the health of those engaged in them, if properly worked, and the poudrette is not allowed to decompose.

*Air of churchyards and vaults* is richer in $CO_2$ and organic matter than ordinary air; and in vaults there are also hydrogen and ammonium sulphides, nitrogen, etc., so that cemeteries, thickly crowded with dead, have a lowering effect upon the health of the people living near, and increase the amount of sickness and mortality.

The effluvia from putrefying human bodies has been known to cause asphyxia, febrile attacks, gastric disturbances, pneumonia, pulmonary abscess, etc.

The effluvia from the putrefaction of horses killed in campaigns causes diarrhœa, and aggravates all other diseases.

*Air of brickfields.*—The kilns evolve carbon dioxide and monoxide, hydrogen sulphide, and sulphur dioxide, and a peculiar smell, which may be perceptible several hundred yards off. If only coal-dust be used, it may not be so offensive, but round London and towns remote from coalfields, the contents of dust-bins and other refuse are used, with the evolution of offensive vapours, and there is also a sickening stench from the accumulation of such refuse, especially in warm weather after rain. The air, as it escapes from kilns, is rapidly fatal, but it is soon diluted and respirable. The smoke and gases from cement-works destroy vegetation near.

*Air from bone-burning, tallow-making*, and other offensive trades, is full of very disagreeable animal vapours, which are certainly a nuisance, if not always injurious to health.*

*Air of marshes.*—Hydrogen sulphide is given off by marshes containing sulphates in the water; sulphides are formed by the action of organic matter, and $SH_2$ is liberated by the vegetable acids. Carbon dioxide, marsh gas, and organic matter are also present with various vegetable and animal matters, including the bacillus malariæ, to which Klebs attributes malarious fevers.

* *Vide* Public Health Act, 1875; the Model By-laws, and Dr. Ballard's report on 'Effluvium Nuisances.'

## Ventilation.

The secret of efficient ventilation consists in the constant supply of fresh air in such quantity as to replace that vitiated or exhausted by heat and by the occupants of the rooms, at such a velocity as to be imperceptible as a draught.

The *Quantity of air required* to dilute or remove the respiratory impurities caused by healthy persons should be sufficient to remove all sensible impurity.

The maximum amount of respiratory impurity admissible in a properly-ventilated air-space is 0·2 per 1,000, and as 0·4 already exists, the total amount permissible should not exceed 0·6 of $CO_2$ per 1,000.

As 0·6 of a cubic foot of $CO_2$ per head per hour is exhaled, in order that the total impurity do not exceed 0·6 per 1,000, it is necessary that fresh air be admitted at the rate of 3,000 cubic feet per head per hour to a mixed community in good health, and in repose.

For adult males... 3,600 cub. ft. (1 cub. ft. per second).
" " females 3,000 "
" children ...... 2,000 "

Adult males at work evolve more $CO_2$, and should have

In light work... 4,750 cub. ft. of fresh air per man.
" hard " 9,800 " "

Large cattle, as horses and cows, ought to have from 10,000 to 20,000 cubic feet per hour.

*Amount required for the sick.*—The smell of organic matter is felt among the sick when the $CO_2$ has reached a much smaller amount than in the case of the healthy. The maximum amount of fresh air should be increased by *one-fourth.* In typhus, small-pox and plague too much fresh air cannot be given.

*Humidity* bears a certain proportion to the other respiratory impurities; thus less than 0·2 per 1,000 has a mean humidity of 73 per cent.

*Quantity of air required for lights, etc.*—A gas-burner consuming 3 feet per hour requires 5,000 cubic feet of fresh air. Nearly as much air must be given for 1 lb. of oil as for 10 feet of gas.

*Cubic space.*—The minimum amount of cubic space allowable is calculated from the rate at which air can be taken through a room without the movement being perceptible or injurious.

The ideal initial air-space should be from 1,000 to 1,200 cubic feet for each person.

It is better to have a large than a small cubic space, because if anything interferes with the ventilation the ratio of impurity from respiration increases much faster in a small than in a large room.

It is a grave mistake to suppose that increased cubic space does away with the necessity of introducing fresh air or of changing the air in the space; after a very short time—whether the air-space be small or large—the same amount of fresh air (3,000 feet) must be supplied every hour, and in this climate it is not found possible to change the air of a room oftener than three times an hour; the air-space, therefore, should contain one-third the amount of air supplied per hour. With good warming and equable movement there would be a better distribution of the air, and the initial space might then be smaller.

The warmth of moving air influences the sensation of persons exposed to it thus:

| | |
|---|---|
| At 55° or 60° F., a rate of | $1\frac{1}{2}$ feet per second (1 mile per hour) is imperceptible. |
| " " | 2 to $2\frac{1}{2}$ feet per second (1·4 to 1·7 miles) is imperceptible to many, and this is a good speed for air to enter rooms. |
| " " | 3 feet per second (3 miles) is perceptible to most. |
| " " | $3\frac{1}{2}$ feet per second is perceptible to all. |

Over that would be felt as a draught, especially if the entering air be of a different temperature or moist.

At 70° F. a rather greater velocity is not noticed, but above 80° F. or below 40° F. the movement is rather more perceptible.

Our soldiers are only allowed 600 cubic feet per man, and phthisis is very prevalent among them in consequence.

Three hundred cubic feet is the quantity specified in the model by-laws for common lodging-houses, and two children under ten count as one adult.

In hospitals, the cubic space should be 1,500 to 2,500 feet, with at least 72 square feet per bed (H. Acland); 100 or 120 square feet would be better. A minimum floor space must be insisted upon in all cases, and it should not be less than one-twelfth of the cubic space.

For horses, 1,200 to 1,800 cubic feet, with 100 to 120 square feet of floor should be given; roughly, 2 cubic feet of space for every lb. avoirdupois the animal weighs —the floor space being not less than one-twelfth of the cubic capacity. Dr. Ballard recommended that cattle should have at least 1,000 cubic feet allowed per animal.

*Ventilation* may be effected in two ways:

1. By taking advantage of natural forces.
2. By the use of mechanism.

1. *Natural Ventilation:*

*Diffusion.*—Every gas diffuses inversely as the square root of its density. Diffusion goes on through the pores of various solids, such as brick or stone, but plastering and papering reduce diffusion through the walls of houses to a minimum; it goes on, however, through chinks and openings produced by imperfect carpentry, but not to an extent sufficient to keep the air pure; moreover, although the carbonic oxide may be got rid of to some extent, the organic matter which does not obey the above law, and which exists in clouds in a room, is not appreciably affected.

*The action of winds:* (1) *By perflation.*—If the wind can pass freely through a house or a room the air will be changed a great many times, but the direct action of the wind is diminished when a through current cannot be obtained, as in houses built back to back, in alleys and narrow streets, or when windows and doors are not suitably placed, or obstructions in the shape of furniture, etc., exist.

The wind will pass through walls of wood (single-cased), and through bricks and stone, especially when there is a difference in temperature and moisture; plaster and mortar act as obstructions.

The great objection to ventilation by wind in this way is the uncertainty of movement and difficulty of regulation.

(2) *By aspiration.*—A small current of air at a high velocity can set in motion a large body of air, by driving

the air before it. A partial vacuum is produced, towards which all the air in the vicinity flows at about right angles, thus the wind blowing over chimneys or other tubes draws up the air ; it may, however, obstruct the exit of air by blowing against the opening; this may be prevented by the use of a cowl.

The ventilation of ships is carried out by utilizing wind by means of cowls, tubes, etc. When the air of a room or hold of a ship is colder than the external air, and when artificial means of ventilation cannot be used, this method may be adopted.

(3) *By the difference in the weights of masses of air of unequal temperature.*—This is, of course, the cause of wind, and by it rooms, which are hotter than the external air, may be efficiently ventilated; it is, therefore, more active in winter than in summer.

*Various methods.*—In all the numerous methods employed to effect ventilation certain points must be observed. The air supplied should not be derived from an impure source nor drawn through dirty tubes or basements. All delivering shafts should be short, accessible, and easily cleaned. If the air is dirty, it should be filtered—fine wire gauze is commonly used, but soon clogs, and causes delay in the current from friction. Coarse jute cloth (light Hessian) makes a good filter, which can be easily and cheaply replaced (Carnelley), or the air may be made to impinge upon a tray containing water or some disinfectant fluid in which dust, soot, etc., will be deposited.

The air should be *warmed* or *cooled*, according to the season or locality, before entering the room. The *distribution* of the fresh air should be uniform; this can be ascertained by calculating from the observed $CO_2$ the amount of air used and comparing it with the actual movements of the air as measured with an air meter ; the two quantities should not differ materially.

The *outlet* for vapours or gases should be in the upper part of a room ; for heavy powders, in the lower part.

*Friction* interferes largely with proper ventilation, and must be calculated for in any system. The causes of friction are:

The *length* of the tube or shaft—the longer the tube the greater the friction. The *size* of opening—for similar sections the friction is inversely as the diameter ; or, if the shapes be not similar, the ratio is as that of the square roots of the respective areas (Morin). Thus, if an opening be divided into so many smaller ones there is great loss from the friction set up.

*Shape* of opening.—A circular opening includes the greatest possible area within the smallest periphery. The loss by friction from use of any other shape will be in the proportion of the lengths of the peripheries.

*Angles* are the most serious cause of loss in velocity of currents in tubes; every right angle diminishes the current one-half; angles should be avoided as much as possible, but when they must be employed should be rounded off. The presence of dirt, soot, etc., also causes friction.

The openings of shafts should be circular or elliptical, as there is less loss by friction and less chance of lodgment of dust, etc., and they can be more easily and thoroughly cleaned.

To obtain perflation by the wind to the best advantage, windows should be placed on opposite sides of the room. Various simple contrivances may be adopted to direct the currents of air, as oblique holes in the glass, double panes, louvres, raising lower sash and a piece of wood placed below it so that air enters at the space between the sashes (Hinckes Bird), or holes may be cut at the junction of the upper and lower sashes; double ceilings, the lower perforated and the space between open to the air, have been suggested for workshops and factories (Stallard).

*Special openings* may be provided: a cowl has no advantage over an open tube, which may be provided with a conical cap and a flange for an up-draught, or with trumpet-mouth and inverted conical cap for a down current. Ellison's conical bricks have cone-shaped holes pierced in them, the smaller end of the cone being outermost; the entering air is distributed so that no draught is felt, even close to the openings. In the above-named contrivances the movement caused by the difference of weight of unequally heated bodies of air also acts; but, as the external temperature in this country necessitates closing of windows and doors, it is desirable to have special openings by which ventilation may be regulated. It is necessary to provide inlet, entrance, or adduction openings as well as outlet, exit, or abduction ones.

*Size of all openings.*—This is difficult to fix exactly, as it depends not only upon the height of the column of air but also on the temperature, which is a variable quantity. Tables have been constructed from Montgolfier's formula,* showing the velocity of the air with varying height and temperature by finding the difference in the pressure of the air inside and outside the room. Dr. De Chaumont suggested this formula for the same purpose :

$$8\sqrt{\frac{(h-h')\ (t-t')}{491}} = \text{velocity in feet per second.}$$

When $h$ = height of aperture of exit from ground.
$h'$ = height of aperture of entrance from ground.
$t$ = temperature of the inside air in degrees Fahrenheit.
$t'$ = temperature of the external air in degrees Fahrenheit.
$\frac{1}{491}$ = the ratio of expansion of air for each degree Fahrenheit.

An allowance of one-quarter to one-half is usually made for loss by friction. To ascertain the amount of air entering a room in a given time, multiply the ascertained velocity by the area of the inlet.

The average size per head for the inlet opening should be 24 square inches, and the same for the outlet. In a small room this could not be borne unless the air were warmed in cold weather. It is better to have several small inlet openings than one large one, distribution being better carried out. Thus each inlet opening should be of sufficient area for not more than two or three persons, and each outlet not more than one square foot, or enough for six persons. Inlet tubes should not be placed too near an outlet ; if placed at the bottom of a room, the air must be warmed ; if placed higher, the tube should end in a trumpet-shaped form, and so turned that the air may be directed upwards. The air may be warmed by (*a*) passing through boxes containing hot water or steam pipes ; (*b*) or by passing it into air chambers behind or round grates and stoves ; (*c*) or in a tube passing through

* The velocity in feet per second of a falling body = eight times the square root of the height through which it has fallen.

a stove. 'Tobin's tubes' are well known for the introduction of air from the outside. The 'Crosse Inlet Ventilator' has certain advantages over the vertical forms : it does not draw the supply of air from near the level of the ground, there is no projection into the room, the air can be heated or cooled, cleansed and charged with a disinfectant if necessary, and the force and quantity of the air can be regulated.

*Outlets.*—For small rooms the chimney is the best outlet that can be had. An ordinary fire will pass through it from 3 to 6 cubic feet of air per second. When other outlets have to be provided they should be placed at the highest part of the room, the tubes protected as much as possible between walls and with a cap to prevent entrance of wind and rain, else the air in the outlet tube will become cooled so that it cannot overcome the weight of the superincumbent atmosphere. All outlets should be placed at the same level in a room. Valves or flanges may be placed in the tubes to prevent down-draughts. When heat can be employed, the discharge of air is rendered more certain and constant, hence advantage should be taken of the heat from the open fire by making an opening, with a talc valve, into the chimney at the highest part of the room, or by surrounding the flue with extra tubes leading the foul air from the other parts of the room, if it be a large one. The heat from gas-burners may also be utilized by having an outlet-pipe over the burner.

2. *Artificial Ventilation :*

This is effected in one of two ways, viz. : By extraction or by propulsion.

*Extraction*, by which the air is drawn out of a building, may be by use of heat, the steam jet, or by a fan or screw.

With an ordinary sitting-room open fire there is a constant current up the chimney even in summer. Without a fire there is often an up-draught. It may be taken as an average that the chimney affords an outlet sufficient for four or five persons. A down current, sending puffs of smoke into the room, shows that there is an insufficient supply of fresh air, and an inlet should be provided. Extraction of the air of a whole building may be performed by a central shaft having a fire in its base, or hot water or steam pipes may be used instead. In theatres the heat from the chandeliers may be utilized for the same purpose. The burning of 1 cubic foot of gas will cause the discharge of 1,000 cubic feet of air.

Objections: Inequality of draught due to atmospheric influences and to changes in the quantity and quality of the combustibles.
Inequality of the movement from different rooms.
Possibility of the reflux of smoke and of air.
Impossibility of controlling the places where fresh air enters.

A steam-jet can be employed in factories; it is allowed to pass into the chimney; tubes passing from the different rooms enter the chimney below the steam-jet, which will set in motion a body of air equal to 217 times its own bulk. An extracting fan or Archimedian screw is used for the same purpose in some mines, in dusty mills, etc.

*Propulsion* methods of ventilation.—Fresh air is driven in so as to force out the air already in the room. This is usually done by means of fans (as the Blackman Air-Propeller); the amount of air delivered can be told by ascertaining the speed of the extremities of the fan per second—the effective velocity is three-fourths of this. Multiply by the section area of the conduit and the discharge can be ascertained. This is the most perfect method of ventilation, as the air is under complete control in every way.

The Punkah is an air-propeller, but not so perfect in action. A modification of it, introducing chemical purifiers, has been recommended for tunnels, hospitals, rooms, etc., by Dr. R. Neale.

Disadvantages: Unless spare power can be obtained from an engine *in situ* the cost of this method is large; chances of the engine breaking down; attention required for details; and some difficulty in distribution. The use of a water-spray to set the air in motion, as in Verity's system, is equally useful and less expensive.

*The relative Value of Natural and Artificial Ventilation.*

The special conditions of each case must determine the choice of method best suited.

Natural ventilation is cheaper than any form of artificial, and is suited for dwelling-houses, barracks, and hospitals.

In the tropics, with warm stagnant air, and in temperate climates, in buildings with numerous small rooms, or where sudden assemblages of people take place, mechanical ventilation is indicated. For schools, Prof. Carnelley finds that better results are obtained from mechanical ventilation. He states that the air is better distributed, $CO_2$ is less, micro-organisms are fewer, the temperature is more equable, draughts are prevented, and that a higher Government grant is obtained by the children in schools mechanically ventilated than in those depending upon natural ventilation only.

*To determine the Sufficiency of Ventilation.*

The cubic space and floor space per person, and the relation to each other, and the number of cubic feet of fresh air which each person receives per hour must be ascertained, and the air must be examined by the senses, and by chemical, biological, and mechanical methods.

(1) *Cubic space.*—This is ascertained by multiplying the length, breadth, and height of a room into one another if the room be a square or oblong one with a flat ceiling; if of irregular shape, then according to the following formulæ:

*Circles.*—To determine areas, circumferences, etc., use is made of the fact that the circumference is 3·1416, or, roughly, $3\frac{1}{7}$ times the diameter, thus:

| | | |
|---|---|---|
| Area of circle | = | $D^2 \times 0{\cdot}7854$. |
| " " | = | $C^2 \times 0{\cdot}0796$. |
| Diameter of circle | = | $C \div 3{\cdot}1416$. |
| Area of a square | = | length × breadth. |
| Area of rectangle | = | length × breadth. |
| Area of triangle | = | Base × ½ height, or height × ½ base. |
| Area of any figure bounded by right lines. | = | Divide into triangles and take the sum of their areas. |
| Cubic capacity of a cube or solid rectangle. | = | Multiply together the length, breadth, and height. |

| | | |
|---|---|---|
| Cubic capacity of a solid triangle. | = | Area of section (triangle) multiplied by the height. |
| Cubic capacity of a cone or pyramid. | = | Area of base × $\frac{1}{3}$ height. |
| Cubic capacity of a dome. | = | Area of base × height × $\frac{2}{3}$. |
| Cubic capacity of a cylinder. | = | Area of base × height. |
| Cubic capacity of a bell-tent. | = | That of a cone resting on a short cylinder. |

Cubic capacity of a hospital marquee, a building with a dome, or such like, may be found by dividing the room into several parts and measuring them separately.

Any recess containing air should be measured, and the amount added. Deductions calculated from actual measurement have to be made for solid projections, large pieces of furniture, bedding (a soldier's hospital mattress, pillow, three blankets, one coverlet, and two sheets occupy about 10 cubic feet), and for the bodies of persons living in the room (the weight of a man in stones divided by 4 gives the cubic feet he occupies)—roughly, 30 cubic feet per head will cover all deductions. It will be found convenient and a saving of time at examinations to use decimals of a foot instead of inches. Square inches may be turned into square feet by multiplying by 0·007. It is not usual to take into consideration any space higher than 14 feet from the floor, as the organic matter does not rise above this height as a rule. The total number of cubic feet, after all additions and deductions have been made, is then to be divided by the number of persons living in the room; the result is the cubic space per head. Total area of floor space divided by number of persons gives the floor space per head, which should be one-twelfth of the cubic space.

(2) *Movement of air in a room.*—Note various openings, the distance between them, how they open, and on what

external place they open ; ascertain in what way the air moves in the room by means of smoke from smouldering cotton velvet, noting the apparent rapidity ; measure the various openings—the chimney should be measured at its throat, or narrowest part. It is only necessary to measure the discharge through the outlets, as a corresponding quantity of fresh air must enter ; but the amount of movement in both inlets and outlets may be measured by Casella's *Anemometer*, or air meter, which should be placed well into any shafts or tubes at a point about two-fifths from the sides of the tube, so that the little sails may be made to catch the centre of the current of air ; the mean velocity will then be registered on the dial. If this linear discharge be multiplied by the sectional area of the opening, the cubic discharge is obtained ; this should then be calculated per hour and divided by the number of persons in the room, which will yield the discharge per head for that particular opening. A manometer, or pressure gauge, should be used instead of the anemometer for chimneys or other places where there is either dust or heat. The velocity of the current is calculated from the height to which it drives a column of water. In recording the velocity of air at openings, it is usual to denote an incoming current by a plus sign, and an outgoing by a minus. If the ventilation of a room is influenced by the wind, the horizontal movement of the external air should be determined by an air-meter.

When the final analyses are made, the amount of air supplied and utilized should be compared with the amount of movement as shown by the air-meter. If the distribution is good they will agree fairly ; if they differ, an excess by the air-meter means bad distribution ; a deficiency indicates that some inlet has been overlooked. If the external air is tranquil and the air in the room is uninfluenced by it, the amount of discharge may be calculated approximately by the law of Montgolfier.

*Examination of the Air of Rooms, Sewers, etc.*

1. *By the senses.*—The degree of smell of animal organic matter in a room may be taken as the measure of the $CO_2$. The humidity of the air has a very marked influence in rendering it more perceptible. The effect of

an increase of one per cent. in the humidity is as great as a rise of 4°·18 F. in temperature; but on the average the smell of organic matter is perceptible when the $CO_2$ reaches over 0·6 per 1,000 volumes, and is very strong when the $CO_2$ amounts to 1 per 1,000.

2. *Microscopical examination.*—The existence and character of suspended matters is judged of by immediate observation under the microscope, and after cultivation in prepared nutrient media.

Pouchet's aëroscope may be used to collect the suspended matters which are collected on a drop of glycerine, or air may be drawn through distilled water, or through glass threads dry or wet with glycerine.

A good way is to take a small bent tube, wash and dry it, heat it to redness; when cool place in a freezing mixture, fix an india-rubber tube at one end, and then air may be slowly drawn through; the water of the air will condense in the tube and carry most of the solid particles with it; a drop may then be taken on a glass rod previously heated to redness and examined at once on a clean glass with an immersion lens.

Or Hesse's method may be employed; the air is drawn through a tube containing nutrient gelatine, which has been previously sterilized; on this moulds, fungi, and other micro-organisms grow, and can be examined. It will be found that moulds and fungi preponderate in pure air, whilst in air rendered impure by the presence of organic matter derived from respiration, etc., microbes are in excess.

To draw the air through the tube an aspirator is used, and may be made thus: A square tin vessel with a tap below and a small opening above to receive the india-rubber tube; fill the vessel with water, attach the tube; then, when the tap is turned on, the air will be drawn through the tube; the water should be measured as it runs out, so as to ascertain the quantity of air which passes through. At 39° F., the maximum density point of water, an imperial pint contains 34·659 cubic inches. 1,000 fluid ounces = a cubic foot.

Dr. de Chaumont considered that the best plan was to carry the air through a succession of bottles containing pure distilled water, the sediment could then be examined microscopically and the liquid part chemically.

3. *Chemical examination:*

*Carbon dioxide.*—A bottle capable of holding a gallon ($4\frac{1}{2}$ litres) is filled with water in the place the air of which is to be examined, and slowly allowed to drain out; then 60 c.c. of clear lime or baryta water are put in, and the mouth closed with an india-rubber cap. After thoroughly shaking up the lime-water, the bottle is allowed to stand for an hour if baryta water has been used, for six or eight hours if with lime-water. $CO_2$ is absorbed and the causticity of the fluids is reduced: the difference between the first and second degrees of causticity represents the $CO_2$. Oxalic acid is used for this purpose. Deduct 60 c.c. from the total capacity of the bottle (to account for the space occupied by the lime-water) and state the capacity in litres and decimals; divide the c.c. of $CO_2$ by the corrected capacity of the bottle; the quotient is the c.c. of $CO_2$ per 1,000 volumes of air.

Correction must be made for temperature. Add 0·2 per cent. to the result, for each degree above 32° F., and subtract for each degree under.

Correction for pressure is unnecessary unless the place is much removed from sea-level, as 1-10th inch of pressure causes a difference of only 0·26 per cent. To correct for pressure, use this formula:

| | | | | |
|---|---|---|---|---|
| As standard height of barometer 29·92 inches or 760 mm. | : | Observed height of barometer | : : | a : x |

a = $CO_2$ corrected for temperature
x = " " " " and pressure.

None of the methods used are quite accurate, but this of Pettenkofer's is the best and most convenient.

*Carbonic oxide* may be detected by the use of palladium chloride, or by passing air through blood.

*Ammonia.*—The estimation of free ammonia and of nitrogenous matter in air by conversion into albuminoid ammonia is performed by Wanklyn's method, as described under Water Analysis.

The quantity of air drawn through the aspirator must be accurately estimated. The results are calculated in milligrammes per cubic metre (1 cub. metre=1,000 litres =1,000,000 c.c.

The presence of ammonia in the air can be ascertained by exposing strips of filtering paper, dipped in Nessler's solution or in ethereal solution of the alcoholic extract of logwood ; the former becomes yellow, the latter purple.

*Estimation of the oxidizable matters* in the air in terms of oxygen. Potassium permanganate is used for this purpose ; it acts upon the putrescible organic matters, hydrogen sulphide, nitrous acids, tarry matters, etc.

*Nitrous or nitric acids* are determined in the same way as in drinking water from the washings of the air.

*Watery vapour* is ascertained by the dry and wet bulb thermometer, by Dines' direct, or by Saussene's, or Wolpert's horse-hair hygrometer.

The examination of the air of a room should be repeated at intervals ; and simultaneous observations should be made of the air outside. There should be only sufficient lights for working purposes, and no smoking allowed.

At examinations for public health diplomas it is usual to present two large clear glass-stoppered bottles to each candidate in order that he may ascertain what gases they contain. The steps taken in the process should be stated.

The bottles are likely to contain one or more of the following :

Carbon dioxide.
Hydrogen sulphide.
Hydrochloric acid.
Nitrous acid.
Sulphurous acid.
Chlorine.
Ammonia.
Coal gas.
Common air.

Directions for testing :

(1) Note colour—Chlorine, greenish yellow.
Nitrous acid, brown red.

(2) Note smell—Raise the stopper slightly for as short a time as possible, as the gas may escape if present in small quantity ; there is usually sufficient to enable the observer to distinguish what is present.

(3) Note any fumes which escape—Red fumes of nitrous acid.

(4) Use test papers—Moisten them with water and fix them between the stopper and neck of the bottle.

Acids turn blue litmus paper red.

Ammonia turns red litmus paper blue and turmeric paper brown ; papers wet with Nessler may be used.

Chlorine bleaches paper with vegetable colouring.

Hydrogen sulphide turns lead acetate paper black.

Nitrous acid turns starch and potassium iodide paper blue ; so also do ozone, peroxide of hydrogen, and chlorine ; but they do not possess the red fumes, nor do they answer the chemical tests.

Ozone is not soluble in water ; hydrogen peroxide is, and gives a blue colour on addition of chromic acid.

(5) Introduce a glass rod which has been dipped in ammonia ; if hydrochloric acid be present white fumes of ammonium chloride will be formed.

(6) If the contents of the bottle have a smell, and any doubt remains as to the gas or gases, add gently a little water, shake thoroughly, and test the solution.

(7) If the contents of the bottle are odourless, common air or carbon dioxide, or both, are present. Instead of adding plain water add a little lime-water ; shake well. If the fluid becomes milky it shows the presence of $CO_2$. If there be any doubt as to whether more $CO_2$ is present than is in ordinary air, add some lime-water to a clean bottle containing ordinary air ; shake well and compare.

As many gentlemen have not the advantage of a properly equipped laboratory, Messrs. Townson and Mercer, of 89, Bishopsgate Street Within, London, E.C., have, at my suggestion, prepared a chemical set, containing the apparatus and reagents necessary for the qualitative analysis of water and air. The reagents, in glass-stoppered bottles, are arranged round the sides of a box with a well in the centre containing a tray for small articles. It is provided with spirit lamp or Bunsen burner, as required ; the cost is 40s. The set will also be found useful both by those who have gone through a laboratory course and desire to refresh their memories at home, and by medical officers of health who may wish to ascertain the quality of a water before deciding to send it on to the public analyst.

## CHAPTER V

### HABITATIONS, SCHOOLS, ETC.

To ensure healthy habitations five conditions must be observed, these are :

1. A site dry and not malarious, and an aspect which gives light and cheerfulness.
2. A pure supply and proper removal of water.
3. A system of immediate and perfect sewage removal.
4. A system of ventilation which carries off all respiratory impurities.
5. A condition of house construction which shall ensure perfect dryness of the foundation, walls, and roof. This may be secured by draining the subsoil 4 to 9 feet below the foundations, and by paving or cementing under the entire house ; walls should be embedded in concrete, should be made hollow, joined with tie or bonding bricks ; if much exposed to rain or to sea spray, walls may be covered with slates or vitrefied slabs, or with alkaline silicates, or water-glass. A damp-proof course should be inserted in the wall below the floor-level, and it is advisable to have one overhead, where the parapet and lead gutter join. If there be no cellars, the flooring ought to be raised 2 feet above the ground, which should be covered with cement and the space ventilated.

Basement walls are liable to become wet when in contact with a damp soil, even when there are drains and damp courses. In this case a 'dry area' must be formed by building a second thin wall outside and a few inches away from the main wall, or by inserting slabs in a slanting position between the soil and the house wall.

Dampness of walls is caused sometimes by uncoped parapets, want of spouting, or which may be defective ; leaking of cisterns and service-pipes, and by a broken roof.

The walls of a newly-built house are damp from the water used in mixing the mortar, and also that absorbed by the bricks. If salt water or sea-sand has been used in the mortar, it will never dry. The settling of the walls sometimes breaks the drain passing underneath if not properly protected.

### Choice of Sites.

The points to be considered are: (1) Conformation and elevation. (2) Geological formation. (3) Ventilation. (4) Aspect, as to heat and light.

1. *Conformation and Elevation.*—Elevation lessens the pressure of the air and increases evaporation.

Unhealthy sites are: Stagnant valleys and ravines; the junction of hills and plains, especially in the tropics; depressions below plains; marshes. It is necessary to observe the relative amounts of hill and plain, elevation of hills, their direction and angle of slope; the kind, size, and depth of the valleys; the water-sheds and direction and discharge of water-courses; and the amount of fall of plains.

2. *Geological Formation.*—Granitic, metamorphic, and trap rocks, clay, slate, and the hard millstone grit formations yield good sites. They have good slopes, are impermeable, so that water runs off readily, vegetation is not excessive, no impurities are added to air or water. Water is sometimes scarce. Of limestone rocks, hard oolite (made up of small rounded grains) is the best, and magnesian the worst. They resemble those already mentioned, except that there is more tendency to marsh formation, and drinking water is plentiful and sparkling but hard. Pure chalk forms a healthy site, being permeable; but care must be taken that wells are not contaminated. If chalk be marly (mixed with lime and clay) it becomes impermeable and damp; if chalk be underlaid by clay, water accumulates and marshes result. Sandstones, when permeable, are healthy, but the same precautions must be taken as with chalk. Gravels of any depth are healthy unless much below the general surface; permeable soils, if low-lying, are all apt to become contaminated with organic animal matter, and give rise to diarrhœal diseases. Gravel hillocks are the healthiest of all sites. Sands, when pure, are healthy, but are not so if mixed with iron and vegetable sediment (as in the Landes in South-West France), or from underlying clay near the surface, or

from being mixed with magnesium, lime, and soda salts. In cold countries sands are dry and warm, but in hot countries they are too hot unless covered with herbage. Clay, dense marls, and alluvial soils are the most unhealthy ; they are impermeable, and water does not run off them ; they are, therefore, wet and often marshy ; in temperate climates they form cold, damp soils, which favour rheumatism, catarrhs, and neuralgia ; such soils may be much improved by drainage. Cultivated soils are often healthy, but not so irrigated lands, which give a great surface for evaporation and send up organic matter into the air. 'Made soils' are usually very impure, and building upon them should only be allowed after a lapse of time sufficient to allow all impurities to have disappeared ; this will depend on the composition of the refuse, and the ease with which air and water obtain access to it ; under the best circumstances, this may require three or four years.

*Ground Air.*—All soils except the hardest rocks contain air, the loosest sands as much as 40 or 50 per cent. In towns it consists of $CO_2$, ammonia, nitric acid, and sometimes carburetted hydrogen and hydrogen sulphide, coal gas from faulty pipes, air from cesspools and broken or porous drains. This air is in continual movement, especially when the soils are dry. This is caused by the changes of heat in the ground, rainfall, barometric pressure, and alterations in the level of ground water. The warmth of the air in houses would draw this impure ground air up into the house unless the basements be covered with concrete.

*Ground or subsoil water* is that condition in which all the interstices of the soil are filled with water, so that except in so far as its particles are separated by solid portions of soil there is a continuity of water (Pettenkofer). When air as well as water is present the ground is merely moist. Even the hardest rocks absorb some water, but they are usually regarded as impermeable ; while chalk, sand, sandstone, vegetable soils, etc., are called permeable. Humus may hold as much as 40 to 60 per cent. The subsoil water exists at various depths from 2 feet to 300 feet. The level frequently changes, due to rainfall, pressure of water from rivers or the sea, alterations in outfall. A uniformly low ground water is the most healthy, but uniformly high ground water is preferable to one that fluctuates, especially if the limits be wide (Baldwin Latham). Ground water causes a cold soil and a misty air, and its varying level aids the evolution of organic emanations from the impurities in the soil. The diseases which are influenced by the condition of the ground water are : Rheumatism, neuralgia, catarrhs, paroxysmal fevers, wasting diseases of the lungs, and perhaps also cholera, enteritis, and enteric fever. The height of the ground water may be measured by the height at which water stands in wells (local conditions which might affect wells being known). To render the soil drier, deep drainage and opening the outflow are resorted to.

3. *Vegetation* obstructs the sun's rays ; in cold climates the ground is cold and moist, as evaporation is lessened ; the removal of wood renders the climate milder and drier. In hot countries the evaporation from the vegetation is so great as to lower the temperature. Vegetation also obstructs the movement of the air, which may be harmful or the reverse according to position.

4. *Aspect as to heat and light.*—Isolated houses and hospitals should be placed so that they are protected from the prevailing winds, and have as much exposure to the sun as possible.

In towns, houses should be arranged so as to have a due circulation of air, back as well as front, and a due proportion of sunlight ; the height of buildings should be so regulated that they do not shut out the sunlight from neighbouring houses. (See 'Model By-Laws.')

On this point the L. G. B. report on 'Back-to-Back Houses,' by Dr. Barry and Mr. Gordon Smith, may be read with profit ; it shows that the practice of building such houses without provision for through ventilation is still in vogue in Yorkshire towns ; that the system tends to overcrowding, the storing of excreta in the house till dusk, and other evils ; and that mortality from all causes as well as from diarrhœa, pulmonary diseases, phthisis, and the chief zymotic diseases increased *pari passu* with the proportion of back-to-back houses in the district.

*Cellar Dwellings* or '*Underground Dwellings*' (Scotch Act) are objectionable ; the provisions of the Public Health Acts which relate to them should be specially noted.

*Artisans' Dwellings.*—The tenor of the new Housing of the Working Classes' Act 1890, which embodies the Torrens, Cross, Shaftesbury, Housing of the Working Classes, the Labouring Classes' Lodging-houses Acts, 1851 to 1885, should be known.*

The term 'density of population' refers to the proportion of population to a given part of the earth's surface. The smaller the houses in a district the greater will be the local density; thus in Glasgow the average density is 84 persons per acre, while the local density varies from 25 to 348 (Dr. J. B. Russell). Such overcrowding leads to moral and physical degeneration. The smaller houses (one and two rooms) contain twice the amount of carbonic dioxide, four times the organic matter, and six times the number of organisms, than the larger (four rooms and upwards) houses do (Haldane and Carnelley); it is not surprising, therefore, to find that of the children under five years of age who die in Glasgow, 32 per cent. die in houses of one apartment, and not 2 per cent. in houses of five apartments and upwards. Dr. Anderson, of Dundee, has drawn up a table (*Sanitary Record*, October 15, 1887), in which he compares the deaths in the whole population with those in houses of one, two, three, and four rooms and upwards; it shows conclusively that the fewer rooms the higher is the death-rate.

The building of artisans' block buildings on sites previously occupied by small crowded houses has this effect, that they have a death-rate considerably under the general death-rate, whereas previously it was much above it.

There is a choice between self-contained two-story buildings and the block system.

In two-storied houses, while there is more privacy and an absence of stairs, yet the inhabitants must sleep either close to the ground, or directly under the roof.

In the block system if the same number of people are put into the same area, there must be a greater amount of open space around the dwellings, and thus more light and air are obtained than in dwellings of the two-story type. As regards economy of building, one foundation

* See also Model By-laws on Common Lodging-houses and Houses let in Lodgings.

will hold up and one roof will cover four or more stories as well as they will cover two with, of course, somewhat thicker lower walls (Hayter Lewis).

As a rule (Boulnois) the blocks should not exceed four stories in height ; as few families as possible should be brought into contact with one another on a flat or landing ; staircases should be fireproof, about 4 feet wide, and broken by short landings, lighted by large windows open to the external air ; glazed cement or bricks should be used to line the walls of staircases and landings. The w.c.'s and dust shoots should be placed in projecting wings or offshoots from the main buildings ; the fittings should be as simple and effective as possible. Soil-pipes should be external, ventilated with fresh air inlets at bottom, and an inspection chamber where obstructions may be readily removed. A sink, with water laid on, should be supplied to each dwelling, the pipe therefrom being properly trapped, and ending at an open-air trap. Washhouses are often placed on the roof where soft-water may be stored. An essential of these buildings is a large playground for the children.

**Warming of Houses.**—Heat is communicated by radiation, convection, and conduction.

*Radiant heat* warms the body, but not the air to a great extent; it is the healthiest method, as no impurity is added to the air; and it requires an open chimney, which is of the greatest service in effecting ventilation.

Disadvantages :—Much heat is lost; is costly; feeble at any distance (the effect lessens as the square of the distance).

Many attempts have been made to counteract these disadvantages, as by having the fireplace project well into the room ; by narrowing the chimney ; by causing the back of the grate to project so that the flames may play on it (as in Pridgin Teale's ' rifle-backed ' grate) ; by free use of fire-clay at bottom back and sides ; by cutting off supply of air at bottom of grate ; by introducing fresh fuel at the bottom (under-feeding) instead of the top, etc.

*Heating by convection* means that heat is conveyed from one place to another by means of masses of air, while *conduction* is the passage of heat from one particle to another ; as air is a bad conductor of heat, conduction by air is of no use in the warming of houses.

The air is heated by passing over hot stones, earthenware, iron or copper plates, hot water, steam or gas pipes; the air in the room is thus heated, but preferably it should be taken from the outside. The warming surface should not exceed 140° F.; it is best to have a large surface feebly heated so that a large body of air may be gently warmed. If too hot the air acquires a peculiar burnt smell, and is too dry. If the air is unpleasant to breathe on account of its dryness it must be passed over water.

The best plan of heating is one which combines both radiation and convection, such as by having (as in Galton's grate) a large air chamber round the back and sides of a grate; through this the external air passes into the room.

Hot water or steam afford an easily controlled method of heating. Hot-water pipes are of two kinds—'high pressure' and 'low pressure.'

High-pressure pipes (Perkins' patent) are of small calibre with thick walls; one portion of the tube passes through a fire, there is no boiler; the water is heated to 300° or 350° F.

Low-pressure pipes are attached to a boiler; the water is not heated above 200° F. In dwelling-houses 12 feet of four-inch pipe is allowed for every 1,000 cubic feet, and will warm to 65° F. The length of high-pressure pipe required is about two-thirds the above.

Steam-piping is equally good if waste steam can be utilized. Stoves consuming coal, coke or gas are also used.

Red-hot cast iron allows carbon monoxide to pass through in large quantity; the use of wrought iron, or of stoves lined with fire-clay or coated with silicate, will prevent it. Stoves are made with air-chambers round them, as in George's Calorigen, in which gas is used. It is not safe to use a gas-stove without connection with a flue.

'Whole-house' system of heating, if carried out with proper ventilation, is a good plan. All the fresh air entering a house is passed round a stove in the cellar, and then conducted by pipes to the entrance-hall and rooms, or if there is no cellar a calorigen or slow-combustion stove is placed in the hall, which becomes a reservoir of warm fresh air for the rest of the house. In order to assist ventilation and to supply the comfort derivable from an open fire, an asbestos-fronted gas-fire may be used.

*Inspection of Houses, etc.*

*In examining a house.*—On entering inquire as to number of inmates and how distributed, trace all pipes down from roof and find out their use and termination, examine cisterns, examine how the water is laid on and method of supply, arrangements for disposal of refuse and excreta.

Note size of rooms and their position (especially cellars), and compare the air-space and means of ventilation with the number of people inhabiting them.

Examine the general surroundings.

In examining a *river* begin at the highest point, observe the condition of the water there, then work down the stream. Note (1) the state of the river as regards current, clearness, smell, weeds, mud, etc.; (2) pipes opening into river and what they discharge; (3) buildings on the banks, as factories, stables, pigsties, etc.

## School Hygiene.

Apart from the general principles of hygiene which ought to be brought to bear on the erection of school premises, and on the personal treatment of the scholars, there are other special matters to which attention may be drawn.

*Over-pressure.*—The true aim of all education is the production of a well-balanced mind in a healthy body; to this end it is necessary that the powers of observation, reflection, and memory be developed, and that such knowledge as shall be of practical use in life be imparted, while at the same time the physical and moral parts of a child's nature are not neglected, but are properly trained and regulated; the so-called education which 'crams' a child's head with as many facts as will enable him to pass an examination, or earn a 'grant,' is worse than useless, for knowledge so acquired is quickly lost, and the brain is unfitted for proper mental work, and it forms an important cause in the production of the condition known as 'over-pressure,' a condition characterized by headaches, talking in the sleep, irritability, restlessness, inability to fix the attention, and sometimes by sickness.

Sir J. Crichton Browne, who reported on over-pressure in Board Schools, found that 40 per cent. of the children suffered from headaches and other symptoms, which he regarded as evidence that proper adaptation did not exist between the children and their work. The factors, however, in the production of these symptoms are numerous, and may be referred to such causes as the following, besides the strain of preparing for examinations:—home-lessons; bad arrangement of work, necessitating too continuous attention to one subject; punishments by impositions, keeping-in, or caning. A much less amount of mental strain will affect children who have not sufficient exercise; who live in unsanitary conditions, and breathe impure air; who are in delicate health, or growing rapidly, or who are convalescent from illness; who suffer from want of food or indigestion; who have defective eye-sight or ear-troubles. Over-strain tells more on girls than on boys. In the future, consideration will be given to some method of classification whereby age, sex, physical health, individual mental receptivity and idiosyncrasy, and probable career of the children, may be taken into account. The adoption of the Kindergarten system in infant schools is a move in this direction, as in the early years of life the cultivation of the senses and powers of observation and construction is of more importance than the premature stimulation of the powers of reflection and memory.

So dependent is the capacity for attention to and the learning of lessons upon a proper condition of bodily health, that (in the words of Dr. B. W. Richardson and Sir Douglas Galton) it is essential in the interests of the community at large that children should not be forced to attend school unless they are in such a physical condition as to be able to take advantage of, and not be injured by the teaching. Hence in these days of compulsory education it is necessary that the greatest attention be paid to the hygienic conditions of schools, and to the physical state of the scholars.

It is a duty also to supply gratuitously the children of the poorest classes with proper *clothing* and *food*, and even for the children of parents who are better off the supply of a good meal for a small sum is desirable.

*Physical recreation* is a question to which too little attention is paid by those engaged in educational work; the out-door games of boys may be easily directed and controlled, but with girls the use of trained physical exercises is rendered necessary in order to bring all parts of the body into play without any part being over-taxed.

*Eyesight.*—The heavy demands made by school life on the eyesight render it essential that everything should be done to make its use as easy and free from undue or prolonged strain as possible; unfortunately, however, statistics show that this is not done, and that not only are hereditary conditions aggravated, but that to a large extent myopia and other defects in vision are produced. The influences tending to produce these defects may be classified under the four following heads:

1. *A low state of the general health.*

2. *Prolonged straining of accommodation.*—In reading or writing the books or slates should not be nearer the eyes than 12 or 15 inches; the distance is often much less than this by reason of the improper posture which has to be assumed on account of the unsuitableness of desks and seats; the use of which also leads to spinal curvature, badly-developed chests, etc.

Desks should be provided of three sizes in every class-room, and should have seats accurately adapted to them. Each pupil should have his or her own desk and seat. For reading and writing the desk and seat so arranged that a perpendicular line dropped from the edge of the desk should impinge on the edge of the seat, will be found suitable; the difference between the height of the seat and the desk should be about one-sixth the height of the scholar; the desk should slope at angles of 30° for writing, and 40° to 45° for reading.

Seats.—The height of the seat from the ground should correspond to the length of the scholar's leg from the sole of the foot to the knee; the breadth should not be less than eight inches; it should be horizontal and cane-bottomed; there should be a back to the seat, and the top of it should be, for boys one inch lower, and for girls one inch higher, than the edge of the desk; the support given by it should be just below the shoulder-blades of the occupant of the seat (Liebrich); there should be a support for the feet, placed at an angle of 30°.

3. *Inadequate or ill-directed light*, not only in school, but also at home. The amount of window area necessary

for any room must vary with the situation of the windows and other external conditions. Cohn advises that it should equal one-fourth of the floor space, while R. Morris gives this formula as a means to determine it :

$$\text{Area of windows} = \sqrt{\text{length} \times \text{breadth} \times \text{height of room}}.$$

The best direction for light to enter is from the left ; cross-lighting is desirable if the light from the left be the stronger, as the intensity of the illumination is thereby greater, and the windows being opposite is a great assistance in ventilation. The height of the windows from the floor should never be less than 5 feet, light obtained from a lower point is too horizontal and dazzling to be of use ; the best light comes from the highest point, and therefore windows should be carried up nearly to the ceiling. Artificial light is detrimental to the eyes, especially when no measures are taken to carry off the heat and other products of combustion.

4. *Unsuitableness of materials used in teaching.*—All printing and writing should be clear and distinct. No type smaller than pica should be used, and the spaces between words and lines should be relatively wide. Paper should be of a cream colour or pale blue tint and unglazed ; pale ink, greasy slates, and shining black-boards are particularly trying to the eyes. Needlework should not be too fine, nor the sewing lesson too long ; good daylight is essential : a good colour for the material is blue.

*Deafness* is responsible for some of the backwardness of children, for as a result of the examination of over 9,000 children in this and other countries, it is stated that no less than 26 per cent. have some defect in hearing, and are therefore at a disadvantage compared with those hearing normally ; and not only so, but Dr. William Hill has pointed out that the cerebral functions may be hampered by congestions of the veins and lymphatics of the head caused by growths affecting the ear and throat.

'Aprosexia' is a term which has been given by Guye, of Amsterdam, to the condition of inability of school children to fix their attention and other allied neuroses due to this cause.

Children with discharges from the ear ought not to attend school.

Dr. Barr, of Glasgow, in a paper read before the

British Medical Association in 1889, made some useful suggestions :

'The site of a school should be removed as far as possible from noisy works and main thoroughfares; class-rooms should not open directly off main staircases ; walls separating class-rooms from one another or from staircases should be of such material as to form bad conductors of sound. Class-rooms should be oblong, 20 or 25 feet by 15 feet ; the number of scholars in one room should not be more than fifty ; there should not be less than 15 square feet of floor area (150 cubic feet) per pupil.

Children whose progress is unsatisfactory, or who are inattentive, dull, or idle, should have their throats and ears examined.

Such children should be placed near the teacher with the better ear towards him.

Stringent orders should be given prohibiting boxing the ears.

Female teachers in noisy localities or with too large classes to look after have to strain their voices to make themselves heard, and chronic laryngitis is frequently set up thereby.

*Compulsory closure of a school* is sometimes necessary, as during severe epidemics, or when drains, etc., in or near the school are being repaired. This can be effected, not under the Public Health Act, but by means of Art. 98 of the Education Code, wherein it is provided that managers of public elementary schools must comply with any notice of the sanitary authority of the district in which the school is situated, requiring them for a specified time and for a specified reason, either to close the school or to exclude any scholars from attendance. This does not apply to Sunday or private schools.

It is very desirable that teachers should have some instruction in the laws of health, and that they should have sufficient knowledge to suspect the presence of infectious or contagious maladies in a school ; they should know how soon, on an average, a child who has had an infectious disease may be allowed in school again.

# CHAPTER VI.

## CLIMATE AND METEOROLOGY.

*Climate* originally expressed the annual temperature of a place when temperature and latitude were supposed to correspond, but it is now regarded as the sum of the influences connected with solar agencies, the soil, the air, the water (Parkes), or as the general tendency of a district toward mild or severe, average or extreme temperature, moisture, atmospheric pressure.

*Weather* is the variation from time to time in respect of all or any of those conditions.

*Temperature.*—Climates are divided in classes according to temperature, as tropical, temperate, arctic ; into equable and extreme, etc. The temperature of any place depends upon :

1. Geographical position as influencing the amount and duration of the sun's rays.
2. Relative amount of land and water. Land absorbs heat, and gives it out more rapidly than water.
3. Elevation. Temperature declines about 1° F. for each 300 feet of ascent.
4. Aspect, exposure and special conditions.
5. Aërial and ocean currents (warm and cold).
6. Nature of soil.
7. Barometric pressure.

Changes in the temperature of any place are either *periodic* or *non-periodic.* The former depend on day and night, and on the seasons or position of the place in respect to the sun ; such changes are also called *fluctuations ;* they are largely influenced by the distance from the sea and the presence or absence of high lands. The *amplitude* of the daily or yearly fluctuations represents the difference between the day and night temperatures, or between the hottest and coldest months. The terms *limited* and *extreme* are applied to the amplitude of the yearly fluctuations. The terms *equable* and *excessive* are applied to non-periodic variations. Equable, limited or insular climates have slight yearly and daily variations. Extreme, excessive or continental climates have great variations.

The *range of temperature* is variously expressed :

*Extreme daily range* in the month or year is the difference between the maximum and minimum thermometers in any one day.

*Extreme monthly or annual range* is the difference between the greatest and least height in the month or year.

*Mean monthly range* is the daily range added and divided by the number of days in a month (or the difference between the mean of all the maxima and the mean of all the minima).

The *yearly mean range* is the monthly ranges added and divided by twelve. The mean of the month of October and of the last fortnight of April will give an approximation to the mean of the year.

*Isothermal Lines.*—These are lines drawn on maps passing through the spots which have the same mean annual temperature ; but this gives no information of the fluctuations in temperature. A better idea can be obtained from maps which give lines representing the mean monthly range ; maps are also constructed giving the mean summer (*isotheral*) and the mean winter (*isocheimonal* or *isocheimal*) temperatures.

*Pressure of air.*—At sea-level the weight of a column of air is nearly 15 lb. on every square inch ; for each 900 feet of ascent above the sea-level the weight decreases about half a pound.

The weight of a cubic foot of dry air at 32° F. and normal pressure is 566·85 grains ; it is affected by temperature and humidity. Air expands with heat $\frac{1}{491}$th part of its volume for every degree Fahrenheit, and therefore weighs less bulk for bulk.

Air also expands when it takes up moisture, so that, instead of being heavier from the addition of watery vapour, a cubic foot of moist air weighs some grains lighter than one of dry air.

These variations in the condition of the air affect the column of mercury in the barometer, so that when the height of the barometer is known with the temperature and amount of humidity, the weight of a cubic foot of air can be ascertained.

The pressure of the atmosphere is sufficient to raise a column of mercury in a vacuum to a height varying between 28 inches and 31 inches, the average or standard pressure being at 29·922 inches (760 millimètres).

Other fluids, as water and glycerine, are sometimes employed in the construction of barometers. The height to which they would be raised may be ascertained by a simple proportion sum, comparing the specific gravity of the fluid used with that of mercury, thus :

| Sp. gr. $H_2O$. | | Sp. gr. Hg. | | Height of column of Hg. | | Height of column of water. |
|---|---|---|---|---|---|---|
| 1·0 | : | 13·6 | : : | 30 in. | : | $x$ |

To read a mercurial cistern barometer : First ascertain the temperature, then raise or lower the bottom of the cistern so that the ivory point (known as the fiducial point) just touches the surface of the mercury, which will then be of a uniform height ; then the figures on the scale immediately below the top of the column of mercury are to be read. This scale is divided into inches, tenths and half-tenths ($\frac{5}{100}$), but in order to take observations with greater nicety a *vernier* is employed. This is a small scale divided into 25 equal parts, which are equal to 24 half-tenth divisions on the barometer scale, hence each division on the vernier is $\frac{1}{25}$ less than a half-tenth division—that is, $\frac{2}{1000}$ of an inch (0·002 inch).

To use the vernier : Read off the fixed scale to a half-tenth (0·05 inch), then adjust the vernier so that its lowest line is level with the top of the column, see what line corresponds exactly to a line on the fixed scale, and count the number of divisions from the bottom of the vernier ; multiply this number by 0·002, add this to that read off the fixed scale, and the result is the exact height of the mercury. Corrections have to be made for height and temperature.

The *aneroid* barometer is a form in which the pressure of the atmosphere acts on the elastic top of a thin metal box, from which the air has been exhausted.

*Effects Produced by Considerable Differences of Pressure.*

Lessened pressure : The physiological effects begin to be perceptible at about 3,000 feet of altitude. At great heights there is increased pressure of the gases in the body against the containing parts, the superficial vessels swell, and there may be bleeding from the nose and lungs.

Residence at altitudes between 4,000 feet and 7,000 feet produces improvement in digestion, sanguification, and in nervous and muscular vigour (Hermann Weber). The conditions which produce this beneficial effect as well as the curative result in cases of phthisis are :

(1) The atmosphere is calm and still.
(2) The air is greatly rarified.
(3) It is extremely dry.
(4) Solar radiation is considerable.
(5) The air is free from dust and organisms.

The smaller amount of oxygen in the rarefied air is counteracted by the greater purity found at high altitudes as compared with lower ones ; while it is found that the respirations are increased both in frequency and depth, and that eventually there is enlargement of the thorax from hypertrophy of healthy lung-tissue.

That the air is not antiseptic, as has sometimes been claimed, is shown by the presence of infectious diseases from time to time in the dirty ill-ventilated chalets of the peasantry.

Increased pressure decreases the pulse-rate, the number of respirations and evaporation, with increased secretion of urine ; work can be carried on vigorously, but if the pressure be increased to equal more than two or three atmospheres, heaviness, headache, and convulsions may be produced from the increased absorption of oxygen.

It has been observed that when persons who have been working in diving-bells, in 'caissons' (compressed air-chambers for working under water), and in deep mines, come up to the surface they suffer from hæmorrhages and occasional nervous affections.

*Isobars* are lines drawn on meteorological charts through places having the same barometric pressure.

*Humidity :*

The *relative humidity* of the air is the amount of moisture present expressed as a percentage of the amount necessary to cause saturation. Between 70 and 80 per cent. relative humidity is most agreeable to healthy people. The wet and dry bulb-thermometer is employed to determine this and the dew-point. If the two bulbs are of the same temperature, the air is saturated with vapour, and the temperature noted is the dew-point ; the greater the difference between the two bulbs the lower is the relative humidity.

The moisture in the air is due to *evaporation*. This is influenced by temperature, wind, humidity, and rarefaction of the air, degree of exposure or shading, and by the nature of the moist surface. Thus evaporation is greater from moist soil than from water ; greater from sand or clay than from peat-moss, the capillarity of earth being more than that of moss ; vegetation retards surface evaporation but gives off a large amount of moisture to the air, drawing up water from the deeper parts of the soil.

*Uses of evaporation.*—The volume of air is enlarged and made lighter by addition of moisture; thus winds are set up, and there is a constant transfer of water (and with it also heat) from one region to another.

By the *tension* or *elastic force* of aqueous vapour is implied the power of water to rise in vapour at all temperatures ; the higher the temperature the more vapour is required to produce saturation.

*Condensation.*—When the heat goes off the vapour is condensed as dew, rain, clouds, etc.

*The dew-point* is the temperature when the air is saturated with moisture, so that the least cooling causes a deposit of water. The dew-point being ascertained (dew-point = dry bulb – (db – wb) factor of dry bulb), the pressure of the vapour in the air may be found by means of Glaisher's tables, and the *drying power* of the air can be found—that is, how much more vapour it could take up until saturated.

When *dew* is formed there must be air saturated with moisture, a clear sky, and a depression of temperature. An object on the ground parts with its heat and cools the air in immediate contact with it ; moisture is then deposited and prevents further radiation of heat. Anything which obstructs radiation, as the passage of clouds reflecting the heat, or the presence of currents of air equalizing the temperature, prevents the formation of dew. *Hoar-frost* results from freezing of the dew.

*Fogs, mist.*—Masses of cold air coming into contact with warmer and moister masses produce fog. Inequality of surface and movement of masses of air of unequal temperature are essential. In large cities the fogs which occur are consequent upon the artificial heat and smoke from fires, and the humidity derived from rivers while colder air descends from surrounding hills. To the little globules of water the smoke and sulphur adhere, hence the irritating effect when breathing. Such a fog is the 'London fog,' which arrests the diffusion of carbonic acid, causing it to accumulate in streets and houses. Fog also checks loss of heat by radiation, which is beneficial in autumn by rendering the transition to winter more gradual. The clouds which cap hills are usually fogs due to the cooling of moist air by contact with the cold hill-top.

*Clouds* are not a result of terrestrial radiation but of a cooling process commencing in the upper regions of the air itself.

*Rain* owes its origin to the cooling of saturated air, so that the tension of vapour is greater than the air can sustain.

The periodic rains which follow the direction of great aerial currents (as the trade-winds) correspond to the passage of the sun across the equator.

Variable rains are found in the temperate and polar regions : a rainy day is held to be one in which not less than ·01 inch of rain falls in the 24 hours.

*Snow* is due to the freezing of the aqueous vapour in the atmosphere : snow-flakes partially melted in their descent form sleet.

*Hail* formation is probably associated with alteration in the electric tension of the atmosphere.

*Wind.*—Movements of the atmosphere are primarily from west to east, and are due to the motion of the earth ; variations from this are local in origin. The velocity of the wind is ascertained by an anemometer. Winds may be divided into constant, periodical, and variable.

The *Trade-wind* is a wind in the torrid zone blowing throughout the year on each side of the equator, both winds being separated by a region of calms or variable weather (or of constant precipitation from the heavy rains). Harmattan is a local name of a north-east trade-wind which blows from the Sahara to the south of Cape Verd.

*Variable Winds:*

In the Mediterranean there are a number of local wind-names:

*Mistral*, a cold, violent north-west wind affecting the Gulf of Lyons and West Italy.

*Bora*, the north wind of the Adriatic.

*Gregale*, north-east wind affecting Malta

*Levanter* is a steady east wind along North Africa.

*Sirocco* (Spanish, *Solanno*), an oppressively hot moist wind from the Sahara, which blows in spring and autumn, chiefly in Italy, Sicily, and Malta.

*Föhn* is the same wind somewhat cooled after crossing the Alps : it is the south-west wind of Davos Platz and other high Swiss health resorts ; it leads to melting of the snow in spring, increases the humidity of the air, and is prejudicial to cases of chest disease deriving benefit from the high altitude.

At the sea-shore during the day the land gets more heated than the sea, hence there is an upper current from land to sea and a lower one from sea to land, the latter being known as the *sea-breeze*. After sunset the land cools more rapidly than the sea and the currents are reversed, the lower one being called the *land-breeze*.

*Periodical Winds:*

*Roaring Forties* are steady west winds of the North Atlantic, blowing often with much violence in winter.

*Monsoons*.—The term is used to describe winds whose direction shifts with the seasons, and which divide the year, however unequally, between them. They are found in the Indian and China Seas, etc.

*Storms* are described by Prof. John Young as of two kinds. (1) Those due to acceleration of the prevailing winds by increased pressure behind, or by diminished pressure in front, as the Sirocco tornado. (2) Those in which the prevailing direction of the wind is changed, forming *rotatory* storms. They are of regular periodic occurrence in the Indian Ocean (as cyclones), at the West Indies (as hurricanes), and in the China Seas (as typhoons); in temperate regions they are probably due to barometric changes.

The term *cyclone* is now applied to any system of winds blowing round a centre of low pressure (cone or

V-shaped, the pressure increasing towards the circumference).

An *anti-cyclone* is a system of winds with a centre of high pressure (pressure decreasing towards the circumference). The isobaric lines of a cyclone are almost circular, while those of an anti-cyclone are very irregular; the 'atmospheric gradient' (*i.e.*, the rate of increase or decrease of pressure from the centre to the circumference) is usually greater in the former than in the latter.

The tendency of the wind in a cyclone is towards the centre in a spiral form; in an anti-cyclone it is from the centre. The two systems are always in proximity to one another.

Cyclones follow the course of the prevailing winds; hence, as west winds are prevalent in this country, we are able to get 'storm-warnings' from America when a 'depression' is moving towards us.

Cyclones travel at an average rate of 18 miles an hour. Anti-cyclones generally remain in the region in which they are formed, and are associated with warm, sultry weather in summer and with frost and fogs in winter.

There is evidence of an eleven-year periodicity in regard to cyclones and rainfall coincident with the number of disturbances in the sun (as shown by 'sun-spots'). In maximum sun-spot years storms are of much greater frequency and intensity than in years when the sun-spots are at a minimum.

Winds are of the greatest service in purifying the atmosphere, and, as already mentioned, play an important part in ventilation.

### *Heat and Light.*

The sun may be said to give out three kinds of rays, viz., heat, light, and chemical; the rays of light being the only ones visible. It is found that the greatest intensity of light lies towards the yellow part of the spectrum; beyond the red of the spectrum are the invisible heat rays, while beyond the violet are the chemical or actinic rays, also invisible. It is owing to the length of the waves that these are invisible; the length of light-waves diminishes from the red to the violet, the rays beyond the red have too long, and those beyond the violet too short, a wave-length for the eye to see.

The colours produced in the atmosphere are due to the presence of vapour and dust, whereby rays of light undergo refraction and absorption. The phenomenon known as the 'mirage' is due to these causes, especially reflection; the layers of air in contact with the hot desert sands become more heated and less dense than those above them, so that rays of light falling obliquely upon these layers reflect distant objects so that they appear as if close by.

*Twilight and dawn* are due to similar causes. Twilight ends when the sun sinks to 18°, or at most 21°, below the horizon; sometimes there is a secondary reflection from the twilight, which is known as the *after-glow*.

*Diathermancy* designates the property possessed in various degrees by various substances of transmitting radiant heat. Diathermancy is to the dark heat-waves what *transparency* is to light-waves. Dry pure air is perfect in both respects, but bodies which have equal power of transmitting rays of light are very different in their power of transmitting heat-rays; thus glass, water, alum, and the majority of transparent substances do not allow dark heat-rays to pass, rock salt being an exception. Aqueous vapour absorbs a very large amount of dark heat while allowing light-rays to pass with scarcely any diminution (Tyndall); it thus allows the earth to be warmed, and prevents the heat being radiated back into space.

The *actinic* rays are powerful to excite chemical action, and probably it is their influence which renders sunlight a necessity for perfect nutrition and proper bodily development; to them also may be ascribed, in part at least, the benefits derived from 'sun-baths' by sufferers from rickets, etc. These rays have the power of decomposing chloride of silver, and are made use of in photography. Their presence may be demonstrated in another way; the phenomenon known as *fluorescence* has been explained by Professor Stokes to be due to the chemical rays being lowered from a condition of great to one of less refrangibility, so that when they fall upon a screen washed with a solution of sulphate of quinine they will be rendered visible as a blue lustre.

*Atmospheric electricity* varies in intensity periodically, increasing from June to January, and decreasing again to June ; it varies also daily ; experiments at Kew show that the mean electric state of the day is best represented about 11 a.m. Pure air offers little resistance to the passage of an electric current. It is accelerated by cold, retarded by heat. Its accumulation in the atmosphere depends upon the aqueous vapour present. If the formation of clouds is slow, equilibrium is quietly maintained ; but if larger masses of vapour accumulate suddenly, and if these are in opposite (positive and negative) electric states, flashes of lightning pass between them, or between them and the earth, until equilibrium is established. The flash consists of the various constituents of the air, heated to incandescence. Forked lightning is due to the breaking up of the flash by unequal conductivity of different atmospheric layers. Sheet lightning may be due to the reflection of distant thunder-storms.

The *aurora borealis,* or northern lights, is supposed to be of magnetic origin.

It is only by the practical use of the various meteorological instruments that a proper knowledge of them can be gained ; to do this, Scott's instructions will be found of service.

# PART II.

## CHAPTER VII.

### FOOD AND EXERCISE.

*Food.*

FOODS may be divided into two classes—

Nitrogenous and
Non-nitrogenous.

The *nitrogenous* consist of :

1. *The Albuminoids :*
   (*a*)—The *albuminoids* proper, having a composition similar to that of albumen. They are of both animal and vegetable origin, such as albumen blood-fibrin, muscle-fibrin, or syntonin ; myosin, globulin, casein animal and vegetable, legumin, etc.
   (*b*)—The *gelatines*, as gelatin, ossein, chondrin, and keratin.
   (*c*)—The *extractives*, as kreatin, kreatinine, karnine, xanthine.

These are occupied with the formation and repair of all the tissues and fluids of the body ; they regulate the absorption and utilization of oxygen, and the transference of energy. They may, themselves, to a certain extent, form fat, and thereby become oxidized. In the process of digestion they are converted into peptones. The members of group *a* are of similar composition, and may replace one another in nutrition ; they have been called the ‘digestible albuminoids.’ The gelatines have a greater proportion of nitrogen in their composition, and are not of so great nutritive value.

The extractives act as regulators and stimulants to digestion, and are specially needful with the gelatines.

*Non-nitrogenous.*

2. *Fats* or *hydrocarbons* consist of carbon, hydrogen, and oxygen, the proportion of oxygen being less than sufficient to convert the hydrogen into water. Olein, stearin, margarin, butyrin, palmitin are examples of the class. They supply energy and animal heat by their oxidation, and keep up the fatty tissues.
3. *Carbohydrates* contain the same elements as the fats, but have the hydrogen and oxygen in the same proportion as in water. Such are starch, dextrin, cane, and grape sugar, lactose, or milk sugar. They act in a similar manner to the hydrocarbons, but the two groups are not entirely convertible; this group may, in part, be converted into fats by deoxidation, so that when they take one another's place, a different chemical process has to be gone through. They are associated also with, or form a base from which arise, various *vegetable acids*—tartaric, citric, malic, acetic, lactic—which preserve the alkalinity of the blood on conversion into carbonates; and to their action on the phosphates and chlorides depends the varied reactions of other fluids of the body; on oxidation they are capable of furnishing a small amount of energy or animal heat.
4. *Salts*, as sodium and potassium, chloride, magnesium, calcium and potassium, phosphates, iron, etc., exist in all tissues and fluids of the body, and are essential for the support of the bones, and for the regulation of energy and nutrition; the growth of cells is dependent on the presence of phosphates, and digestion on the HCl derived from the chlorides; the soda salts exist chiefly in the fluids, the potash in the formed tissues.
5. Water.
6. '*Accessory foods*,' as tea, coffee, cocoa, and alcohol, have been termed with the salts 'force-regulators.' They give taste to food and excite the alimentary secretions.

Experience has proved to man the necessity of having representatives of all the four classes of foods—albuminoids, fats, carbohydrates and salts—in ordinary diet in certain relative proportions. The omission of one or other is followed by ill-health. This is not so marked when carbohydrates only are absent; excess of fats or of carbohydrates lessens oxidation of the other two classes, and hinders the metamorphosis of both fat and albuminoid tissues; excess of albuminoids causes more rapid oxidation at first, but if the excess be continued the food does not digest, but undergoes fermentative changes, producing dyspepsia, diarrhœa, flatulence, etc. It is probable that ptomaïnes are formed and absorbed into the system. Absence of those vegetable acids which form carbonates in the system produces the condition known as scurvy.

The relative amounts of these foods which should enter into a proper dietary scale have been calculated by various observers. The following table (from Parkes's seventh edition) represents the quantity of water-free food required for work of about 300 foot-tons per day:

| | | |
|---|---|---|
| Albuminoids | 0·031 | ounces avoir. per lb. of body weight. |
| Fats | 0·019 | |
| Carbohydrates | 0·095 | |
| Salts | 0·007 | |
| Total | 0·152 | |

For every foot-ton of work beyond 300 foot-tons add 0·000361 oz. avoir.

For a man of average size and weight (150 lb.), the following amounts (in round numbers, to facilitate calculations) may be taken:

| | | |
|---|---|---|
| Albuminoids | 4·50 | ounces. |
| Fats | 3·00 | ,, |
| Carbohydrates | 14·25 | ,, |
| Salts | 1·00 | ,, |

Theoretically each of the above is absolutely water-free, but practically ordinary food contains between 50 and 60 per cent. of water, the weight of which has to be added to the above, so that the usual average range would be from 40 to 60 oz. of so-called solid food. As 50 to 80 oz. of water are taken in some liquid form in addition to that contained in solids, the total amount of water is stated by De Chaumont to be from 70 to 90 oz., or 0·5 oz. for each lb. weight of body.

*Amount of nitrogen and carbon.*—It is necessary in arranging dietary scales to see that these two elements are present, not only in proper quantity, but in proper proportions. For ordinary work the amount of nitrogen in the diet may be taken as 300 grains, carbon as 4,800 grains ; the best proportion is nitrogen 1 to carbon 15. In order to calculate how much of any particular article or articles of diet should be consumed in order to give the requisite amounts of these elements, it is necessary to have an analysis of the foods in question, as in the following table. One oz. (437·5 grains) contains in grains :

| Substance. | Water. | Nitrogen. | Carbon. | Salts. |
|---|---|---|---|---|
| Uncooked beef ... | 328 | 12 | 60 | 7 |
| Cooked beef ...... | 236 | 19 | 110 | 13 |
| Bread ............... | 175 | 5 | 120 | 6 |
| Oatmeal ............ | 66 | 8·8 | 168 | 13 |
| Potatoes ............ | 324 | 1·4 | 45 | 4 |
| Butter ............ | 26 | 2 | 30 | 12 |
| Milk (sp. gr. 1·029 and over) ...... | 380 | 2·8 | 30 | 3 |

From the analysis, by stating an algebraic problem, it is possible to determine how much of each ingredient in a dietary scale should be allowed to give the proper proportions of nitrogen, carbon, etc. (See Appendix.)

Another way is to calculate out the dry albuminoids, fat, and carbohydrates in ounces, and make use of the following figures :

| | | | |
|---|---|---|---|
| Albuminoid 1 oz. | contains 70 grs. nitrogen, | 212 grs. | carbon |
| Fat | „ „ | 336 grs. | „ |
| Carbohydrates | „ „ | 190 grs. | „ |

An allowance of 30 grains of carbon has been deducted from the albuminoids, as this amount is converted into urea, and is therefore not capable of being fully oxidized.

Almost every article contains some portion (5 to 10 per cent.) which cannot be utilized on account of its indigestibility, much, however, depends upon the variety of food employed and the way in which it is prepared, in order that the nearest approach may be made to obtaining the theoretical value therefrom.

### *Meat.*

Theoretically it is immaterial whether the nitrogen in food is derived from animal or vegetable sources, but long use has rendered one form more acceptable and more easily digested than the other. Animal food contains a large amount of nitrogen, much fat and important salts, but no starch : it is easily cooked, and appears to be more quickly assimilated than any vegetable : change of tissue takes place more quickly in meat-eaters, so that they require more frequent supplies of food than vegetarians. Animal fats are more easily absorbed than vegetable ones.

*Inspection of dead meat.*—It is desirable that all abattoirs should be public rather than private, so that all the animals killed in the town may be passed through them and properly inspected ; private slaughter-houses are usually near the butchers'-shops, and are therefore generally in central and crowded parts of the town. There are a number of ways in which dishonest traders attempt to pass inferior meat on the market, such as :

(1) Meat of animals which have died from disease, or from an accident, as by drowning.
(2) Meat of animals killed and bled when there is no hope of recovery from illness.
(3) Meat of animals which have been the subject of infectious disease, as foot-and-mouth disease, anthrax, etc.
(4) Meat of tuberculous cattle; the lungs and pleura being removed.
(5) Meat containing encysted parasites.
(6) Meat beginning to decompose.
(7) Horseflesh to be sold as beef ; young goats for lamb.

If the animal be seen alive, it should, *if healthy*, present a well-nourished appearance ; the coat should be soft, supple and glossy, the eye bright and clear ; the flesh should feel firm and elastic ; the mucous membrane of the nose should be red, moist and clean ; the tongue should be moist, warm, clean and not protruding ; the breath should have little odour, and the respiration be quiet and regular ; the udder should be cool ; the dung should appear natural ; the reverse of these conditions indicates disease.

After death the viscera should, if possible, be secured for examination, by naked eye and microscopically, the liver for abscesses or entozoa, the brain for hydatids, the lungs and pleura for tubercle, evidence of abscesses or strongylus filaria, the ribs for pleuritic adhesions, the omentum, peritoneum and diaphragm in pigs for trichinæ.

*Good meat* should have the following characteristics :

The *bone* should be about 20 per cent. of the whole.

The *fat* should be in proper proportion, firm, healthy-looking and free from hæmorrhagic points ; beef-fat is yellow, mutton white. The fat is much influenced by the nature of the food ; thus, oil-cakes produce a deep yellow colour, and flesh-fed pigs have a soft, diffluent fat.

The *flesh* should be firm and elastic, with a marbled appearance ; the surface should not be too moist ; there should be no lividity on cutting across any of the muscles, and no softening, mucilaginous fluid or pus in the inter-muscular cellular-tissue. Any juice exuding from the meat should be small in quantity, of a reddish tint, neutral in reaction immediately after death, but becoming acid in about four hours. Good meat should dry on the surface after standing a day or two. The colour varies with age : it should neither be too pale nor too dark ; if pale and moist, it indicates that the animal was young or diseased ; if dark and livid, in all probability the animal was not slaughtered, but died with the blood in it. The odour of meat is important : beef has a special, insipid, but not unpleasant kind of smell ; veal smells of milk, mutton of wool ; pork has little smell, unless flesh-fed, when it emits an offensive odour. Commencing putrefaction is detected chiefly by the colour, loss of elasticity ; later, by the change in odour. Diseased meat has often a disagreeable odour ; this is especially noticeable underneath the shoulder and in the muscles of the internal crural region. An incision may be made, or a clean knife pushed in will, on withdrawal, convey any particular odour ; if in the latter place, it may be possible to detect the smell of physic (aloes, etc.) ; the odour will also be given off if meat be chopped up and drenched with warm water. The resistance offered to the entrance of a knife gives another test in good meat—it is uniform, while putrefying parts of the meat are softer than others.

The *marrow* should be light, rosy red, and solid for twenty-four hours after killing ; if soft, brownish, or with black points, the animal has been sick, or putrefaction has begun.

If tuberculosis be suspected, and the animal has been 'dressed' the marrow may be examined for bacilli.

In *cattle plague* the mouth, stomach and intestines must be seen; microscopically the muscles will be found to be degenerating.

*Horse-flesh* is much coarser than beef and of darker colour. By recent enactment penalties are imposed for selling flesh of horses, mules, or asses when some other meat has been asked for; and a large notice must be placed in a conspicuous position indicating that horse-flesh is sold there. (The Horse-flesh Act, 1889.)

*Diseases produced by altered quality of meat.*—Poisonous symptoms sometimes ensue after eating apparently sound cooked meat, especially when it has been allowed to get cold before being consumed. This is explained by the fact that microbes produce ferments which are not affected by cooking; these ferments are not themselves poisonous, but if allowed time to act on the albumen of the meat, will produce certain toxic alkaloidal bodies. (See Chapter VIII., on 'Communicable Diseases,' p. 146.) Various kinds of fish have also produced similar effects, as well as causing dyspepsia and urticaria.

The poisonous symptoms are of two kinds, one with violent gastro-intestinal irritation, cramps and cardiac failure, as in muscarine poisoning; the other of an ataxic nature, accompanied by great depression, diminished mucous secretions, quickened pulse, paralysis of the muscles of the eyeball, etc.*

With the exception of the above, meat from diseased animals may, as a rule, be eaten with impunity if thoroughly well cooked. It is when cooking has not been complete that danger occurs; and as this is always liable to happen, it is therefore desirable to prevent the flesh of animals that have had communicable diseases being used for food. The following are the principal:

Tuberculosis
Epidemic pleuro-pneumonia.
Anthrax, malignant pustule, charbon.
Erysipelas carbunculosum, black quarter.
Splenic apoplexy, braxy of sheep.
Small-pox of sheep.
Foot-and-mouth disease, aphtha or eczema epizootica.
Cattle-plague, rinderpest, typhus contagiosus.

* See Dr. Ballard's report on the Welbeck, 1880, and Nottingham, 1881, cases.

Scarlet fever.
Actino-mycosis.
Pig typhus, hog cholera, swine fever.
Glanders and farcy.
Fever after parturition.
Entozoa—cysticerci, trichinæ, echinococci.
Pyæmia, septicæmia.
Uræmia.
Gangrene (as of the navel in calves).
Rabies (or flesh of an animal recently bitten by one rabid).
Various marked cachectic conditions—when marked physical changes have taken place as a result of inflammatory or febrile affections, or important forms of blood deterioration (Walley).

Sometimes poisoning is caused by the presence in the flesh of drugs, such as antimony and arsenic, when they have been given to the animal in large quantities, or if the animal has been poisoned accidentally by poisonous herbs or drugs.

Powers to prevent the sale of certain articles *intended for the food of man* are given in the Public Health Act, 1875, Art. 116-119 ; but under the Markets and Fairs Clauses Act, 1847, Art. 15, which is still in force in some urban districts, it is an offence to have *any* unwholesome meat or provisions for sale in the market.

See also Public Health Act, Art. 166-170, and the Model By-laws, with reference to the establishment of markets and slaughter-houses, and on offensive trades, many of which are connected with the utilization of the refuse from slaughter-houses.

*Slaughter-houses.*—The Local Government Board require :

That they be not situated within 100 feet of any dwelling-house, and so placed as to admit external air on two sides at least.

That the lairs or pens for cattle be independent of the slaughter-house, be properly drained, be at a distance from dwellings, and be just sufficient to hold those cattle about to be killed.

No rooms to be built over slaughter-house.

No water-closet, privy or cesspool to be in slaughter-house, and no direct communication should exist with such or any stable.

Ample cross ventilation and proper lighting to exist.

Floor to be concrete or asphalt, with slope to groove running to a trapped gully outside, whose bars are not more than three-eighths of an inch apart.

Walls to be coated with hard impervious cement or glazed tiles to the height of 7 feet ; above that to be limewashed, with the ceiling, at least four times a year.

Water supply must be sufficient, and there must be provided a galvanized tank at least 6 inches above the floor, and quite independent of it, to contain pure water.

Galvanized iron buckets to be provided, and all blood, offal and garbage removed within twenty-four hours.

In public abattoirs (or group of slaughter-houses, from the French word *abattre*, to fell) good artificial light should be supplied, as much killing is done at night. There should be a separate department for suspected or condemned cattle.

### *Milk.*

Milk is a typical food, containing all the four classes of aliment essential to health, and is especially suited to provide the nourishment necessary during the earlier years of life, when growth is active.

From 20 to 25 pints in twenty-four hours is a good yearly average yield for a cow, but the quantity given, with the specific gravity and composition, varies according to the food and shelter of the cattle, the intervals between milking, the age of the calf, number of pregnancies, breed, age and individuality.

Cows' milk, as compared with other milks, presents certain differences which have an important bearing upon the feeding of infants and invalids.

It contains more casein, fat and salts, than human milk, but from 1·5 to 2 per cent. less milk-sugar.

When taken into the stomach it forms a firm clot, much less easy to digest than the loose flocculent one resulting from human milk, or from that of asses, mares or goats, into which the gastric juices can easily penetrate.

Asses' milk is much poorer in solids, and goats' is richer than cows' milk.

*Examination of milk:*

Average composition.

| | | |
|---|---|---|
| Water ... | ... | 87·0 per cent. |
| Albuminoids | ... | 0·6 ,, |
| Casein ... | ... | 3·5 ,, |
| Milk-sugar | ... | 4·4 ,, |
| Fat ... | ... | 3·8 ,, |
| Salts ... | ... | 0·7 ,, |
| Total solids | ... | 13·0 ,, |

When placed in a tall glass it should be opaque, white in colour, without peculiar smell or taste, and without deposit.

Reaction should be neutral, or faintly acid or alkaline.

*Specific gravity* varies from 10·29 to 10·34; at 60° F. good milk averages 10·30. The specific gravity of the whey should be taken when possible; it is generally about 10·28.

The *total solids* are obtained by evaporation. They should be about 13 per cent., of which 3½ to 4 per cent. is represented by fat; but very inferior samples may contain much less. There is no legal standard, and various minimum limits are in use; thus Somerset House pass milk as unadulterated with only 10·8 of total solids, 2·4 of fat; the Society of Analysts 11·5 total solids, 2·5 fat. Any milk, however, which shows an analysis as low as either of these standards must be open to suspicion.

The *fat* is determined best by the lacto-butyrometer. Microscopically it is seen to exist in minute globules of various sizes, surrounded by an envelope of casein, and being lighter than the fluid in which they float, they tend to rise to the surface to form cream; 3 per cent. of cream is equivalent to about 1 per cent. of fat, so that good milk should yield from 12 to 15 per cent.; but by the ordinary method of taking off the cream, about a third of the fat is left behind; by using the centrifugal cream-separator, nearly nine-tenths may be removed.

'The comparison of the specific gravity, and the amount of cream which rises with the physical characters, will give a very good idea of the quality of milk' (Parkes).

*Adulterations.*—The chief of these are water and annatto.

*Water.*—The addition of water simulates to a great extent the condition of very poor milk; it is detected by the lowered specific gravity, and by the diminished amount of total solids, or of the ash (0·73 per cent.); the various constituents are in normal proportions to one another. Creaming alone gives a higher specific gravity. The cream, of course, is less; but other constituents will be in normal amount. With creaming and watering combined the specific gravity may be normal, but cream will be deficient; quantitatively all the constituents will be deficient, but especially fat.

*Starch, dextrin, gum*, are sometimes used to thicken; for starch, add iodine; for dextrin, boil with drop of acetic acid, then iodine; or add lead acetate, and then ammonia—a white precipitate will fall.

*Annatto or turmeric* is not unfrequently added to watered milk to make it look richer. An emulsion of annatto and borax has been found at the bottom of the glass in which the sample of milk was standing. Liquor potassæ turns turmeric to red orange colour.

*Glycerine.*—Milk is sweeter than usual, and solids will not dry on evaporation.

Salicylic acid, boro-glyceride, boracic acid, and other preventers of fermentation, are sometimes to be found in milk which has been sent long distances, etc.

*Chalk and sodium carbonate* are added to neutralize acidity produced by lactic fermentation. The chalk will deposit at bottom of glass; but the sodium carbonate can only be found by the effervescing of the ash, unless sufficient has been added to give the milk an alkaline reaction.

*Salt* is detected in the ash.

*Lead, copper, or zinc* may be found if milk has been boiled in vessels made of one of those metals.

*Cream* is sometimes adulterated, and even made with magnesium carbonate, tragacanth and arrowroot, etc. The microscope will detect the additions.

*Diseases connected with Milk.*—Milk has the power of absorbing gases and vapours to a great extent, and if these are offensive or noxious they will produce their effects on the body. It also very readily passes through the lactic and butyric fermentations to putrefaction.

Stomatitis, gastric and intestinal irritation, etc., are produced by milk containing lactic acid, or fungi as oïdium lactis, penicillium, aspergillus, etc., or pus, etc., from an inflamed or suppurating udder. These are visible under the microscope.

Tuberculosis, enteric fever, scarlet fever and diphtheria, and foot-and-mouth disease, find in milk a suitable medium in which their germs can grow and be conveyed.

Milk which has been kept for some time may develop a ptomaïne called tyrotoxine, or cheese poison; it has been detected in ice creams, which have proved to be poisonous.

*The Regulation of Dairies, Cowsheds, and Milkshops.*— This is the duty of the Local Government Board and the local sanitary authorities (under the Contagious Diseases (Animals) Act, 1886, England and Scotland; the Privy Council's Order of 1885 was adopted and amended by the Local Government Board; it requires that cowsheds, dairies, and milkshops must be properly ventilated and lighted, and have proper arrangements for water supply, cleansing, and draining.

No person suffering from infectious disease, or in a condition to communicate infection, may take any part whatever in the production, distribution, or storage of milk, or handle any milk-vessels.

It is unlawful to occupy as such any milkshop or dairy having within it, or in direct communication, any water-closet, privy, or cesspool, after the expiration of a month's notice from the local authority.

Local authorities may frame regulations for inspection of cattle, for securing cleanliness of milkshops and milk-vessels, and for prevention of infection.

Milk from a diseased cow must not be mixed with other milk, or sold or used for human food; unless first boiled it must not be used for food for animals. The word 'disease' is defined in the Act as meaning cattle-plague, contagious pleuro-pneumonia, foot-and-mouth disease, sheep-pox or sheep-scab. In Ireland the Dairies Order of 1879 applies under the same Act.

See also the Infectious Diseases (Prevention) Act, 1890.

## *Butter.*

When cream is churned the envelope of casein is broken, and the particles of fat coalesce.

The fat amounts to from 86 to 92 per cent. of the butter, and consists chiefly (88 per cent.) of stearic, palmitic and oleic (non-volatile, insoluble) acids, with butyric, caproic, caprylic and capric (volatile, soluble) acids 6·7 per cent., and glycerine. Butter also contains a little casein, a varying quantity of water; salt should not be more than 2 per cent. if fresh, and 8 per cent. if salt butter.

*Adulterations.*—Water, milk, annatto, and various starches are sometimes added, but the chief adulterants are other fats, chiefly animal—the term oleo-margarine was applied to the imitation butter made from beef fat—when churned up with milk and coloured it was termed butterine, but the Act of 1887 provides that 'all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed with butter or not, shall be included in the term *margarine*, and no such substance shall be lawfully sold except under the name of margarine.' The best quality of margarine is made from a mixture of oleo-margarine, from beef fat, nut-oil, butter-milk, salt butter, salt, annatto and water. If the ingredients used in its manufacture are of good quality, margarine is no doubt wholesome and nutritious.

The means used to distinguish between true butter and its imitations depends upon the fatty acids they contain; if a sample is found to have more than 88 per cent. of the non-volatile fatty acids, it is adulterated. The melting and solidifying points of the various fats are also used as tests.

*Cheese.*

Cheese contains 33·5 per cent. of albuminoids, 24·3 of fats, and 5·4 of salts.

As with butter, so the chief adulterant or imitation is what is known as 'margarine, or filled cheese.' It is not included in the Margarine Act, and has not yet been brought into much public notice, although its sale is believed to be extensive. It is made from skim-milk and beef fat, with colouring matter. Unless eaten new, it is said to become hard and indigestible.

Starch is sometimes added to cheese to increase weight.

To destroy insects, or give a colour to the rind, various metallic salts (copper, arsenic, mercury, lead) are sometimes applied.

Tyrotoxine, lactic acid, and various kinds of moulds may form in decaying cheese.

*Lard.*

A mixture of lard, with water, beef fat, cotton-seed oil, and stearine, is manufactured and sold under the names of lardine, refined lard, and compound lard.

*Eggs.*

An average egg weighs about 2 oz. avoirdupois; 10 parts are shell, 60 white, and 30 yolk; 22·8 per cent. of egg is albumen and fat, 67·2 per cent. is water; hence a 2-oz. egg contains about 200 grains of solids.

*Vegetable Foods.*

**Wheat-flour**, made from the whole grain, contains: Water 15 per cent.; gluten (vegetable albumen) 8 to 10 per cent.; soluble albumen 1 to 2 per cent.; starch, sugar, and dextrine 60 to 70 per cent.; fat 2 per cent.; potash and magnesia phosphates, etc., 1·7 per cent.

If the bran is removed before grinding, the flour is deprived of a large quantity of nitrogen, fat, and salts; when it is allowed to remain it should be ground very fine, else its hard, silicious nature may irritate the bowels.

*Cooking* renders starchy foods more digestible by rupturing the cellulose surrounding the starch granules, to which the saliva and pancreatic juice can then obtain access; the albumen is coagulated and some of the starch is turned into dextrine.

**Bread** is formed by the minute division of the dough by carbon dioxide. This may be produced by the use of yeast, of baking powders, or by forcing $CO_2$ through by pressure (aërated bread). For this last kind of bread the following advantages are claimed: that it contains no yeast, which might produce fermentation in the stomach, or might be impure; that no starch is lost; and that whiter bread is produced. But it may not be so digestible as bread made with yeast.

*Adulteration of bread.*—Very little now exists, but in poor districts damaged or inferior flour is not unfrequently used. Bread made from such flour will be dark in colour, of acid taste, and unpleasant smell. Lolium temulentum, or bearded darnel, may sometimes get into flour by accident; it gives rise to narcotic symptoms.

*Alum* is illegally added in the making of bread in order to arrest excessive fermentation and prevent the formation of lactic and butyric acids, to whiten the bread, to enable inferior flour to be utilized. It lessens the nutritive character of the bread by joining with the phosphoric acid and rendering it insoluble. As unalumed bread may contain from 1½ to 2½ grains of aluminum phosphate per lb., it is necessary to make a quantitative analysis before adulteration can be detected with certainty. Decoction of logwood is sometimes used to test roughly; slips of gelatine are soaked in an aqueous solution of the suspected bread; if the bread is pure, the gelatine is stained only reddish-brown by logwood, and can be decolorised by glycerine; alumed bread gives a blue colour permanent in glycerine (Winter Blyth).

Or, to a clear aqueous solution of the suspected bread, add a few drops HCl and barium chloride; a slight precipitate will probably be due to sulphate of potash or magnesia in the water, or salt used in the baking, or to a slight amount of $H_2SO_4$ naturally existing in the grain or added during the grinding; a large precipitate indicates the probable presence of alum, but it is not certain (Wanklyn).

*Lead* sometimes obtains admission to the flour in the process of grinding, as holes in millstones are often filled with combinations of lead, red-lead, borax, and alum.

A comparison between wheat and other vegetable food-stuffs may be made from the following analytical table by De Chaumont, Letheby, and others; the leguminosæ are remarkable for the large quantity of nitrogen they contain in the shape of legumin or vegetable casein combined with sulphur and phosphorus, but they are somewhat indigestible.

| Articles. | In 100 parts. | | | | |
|---|---|---|---|---|---|
| | Water. | Albuminates. | Fats. | Carbohydrates. | Salts. |
| Wheat-flour ... | 15 | 11 | 2 | 70·3 | 1·7 |
| Barley-meal ... | 11·3 | 12·7 | 2 | 71 | 3 |
| Oatmeal ... ... | 15 | 12·6 | 5·6 | 63 | 3 |
| Rye ... ... ... | 13·5 | 13·1 | 2 | 69·3 | 2·1 |
| Maize ... ... | 13·5 | 10 | 6·7 | 64·5 | 1·4 |
| Rice... ... ... | 10 | 5 | 0·8 | 83·2 | 0·5 |
| Arrowroot ... | 15·4 | 0·8 | — | 83·3 | 0·27 |
| Peas (dry) ... | 15 | 22 | 2 | 53 | 2·4 |
| Potatoes ... ... | 74 | 2 | 0·16 | 21 | 1 |
| Cabbage ... ... | 91 | 1·8 | 0·5 | 5·8 | 0·7 |
| Meat (average) | 74·7 | 17·7 | 6 | — | 1·6 |

The ready recognition under the microscope of the various starches can only be obtained by a careful comparison of their characters. Of the *unfacetted* starches, that of potato should be compared with those of the arrowroots and with pea-starch; wheat-starch with those of barley and rye. Of the *facetted* starches sago, tapioca, and Rio arrowroot with one another, and with unfacetted arrowroots; oats with maize and rice.

The microscopical appearances of plants affected by fungi, or by insects, should be known. Of the fungi smut (uredo segetum), bunt (uredo fœtida), rust (puccinia graminis) affecting the stem and leaf of wheat, ergot of rye (oidium abortifaciens), peronospara infestans of potato disease are the commonest; and of insects the weevil (calendra granaria), the vibrio tritici, and the acarus farinæ, may be mentioned.*

**Beverages:**

*Alcohol* with $CO_2$ is yielded by the fermentation of the glucoses; cane-sugar passing into grape-sugar before the production of alcohol commences. This ethylic alcohol ($C_2H_6O$) is contained in spirits, wines, and beer in varying proportions, and is not unfrequently accompanied by traces of other alcohols (propyl, butyl, and amyl) simultaneously produced; the chief of these is amylic alcohol ($C_5H_{12}O$); it is a constant accompaniment when sugar is used which has been derived from starch. It forms the chief ingredient of 'potato-spirit,' or 'fusel-oil,' and is frequently used to adulterate or to imitate whisky, brandy, and rum.

*Wine* should contain from 6 to 25 per cent. of anhydrous alcohol (over 17 per cent., however, is not produced by fermentation, and must have been added to the wine); a number of ethers, on which depend the 'bouquet;' some albuminous substances and extractives; sugar and other carbohydrates are present in most wines, in some to a large amount; also abundant vegetable salts, which render wine of value as an anti-scorbutic. Wines are adulterated with water, distilled spirits, artificial colouring matters, lime-salts, tannin, alum, lead, copper, logwood, catechu, cider, perry, etc.

* Messrs. W. Watson and Sons, 313, High Holborn, supply a box containing a series of microscopical slides specially arranged for public health students.

*Beer* should contain from 1 to 10 per cent. of alcohol, from 4 to 15 per cent. of extractive matters (sugar and other carbohydrates), bitter matters, and free acid.

Adulterations.—Instead of making beer from malt and hops, numerous other substances are often used by brewers, as capsicum, grains of paradise, aloes, colocynth, santonin, cocculus indicus, and picrotoxine, quassia, picric acid, and, before being retailed, water, coarse sugar ('foots'), 'finings' (made from skins of fish), sulphuric acid, alum, ferrous sulphate, salt (the last three to provide 'head') are not unfrequently added.

*Spirits* are for the most part (50 to 77 per cent.) flavoured alcohol, various ethers, and, sometimes, aromatics and essential oils. They do not contain the ingredients which give a dietetic value to wine and beer.

Lead-poisoning has happened as a result of the drinking of acid wines (especially home-made) which have taken up lead from the vessels in which they have been made.

The intemperate use of alcoholic beverages has a marked effect upon mortality, increasing diseases of the brain, circulatory and digestive systems. The mortality is greater in those intemperate on spirits than in those on beer.

*Total abstinence.*—The evidence which of late years has been forthcoming from life assurance offices, friendly societies, Arctic explorers, African travellers, military commanders, etc., clearly shows that the practice of total abstinence from intoxicants is accompanied by greatly lessened rates of sickness and mortality.

*Non-alcoholic Beverages :*

*Tea* and *Coffee* depend for their restorative properties upon alkaloids (thein and caffein) of similar composition. They contain also much cellulose, tannin, and aromatic oils.

Coffee is adulterated with chicory, cereal grains, beans, potatoes, and sugar. Microscopical examination will readily detect most of these. If a mixture of roasted coffee and chicory be thrown on water, the latter sinks at once, while the former floats for a long time. Chicory is itself adulterated with roasted barley, wheat, acorns, mangel-wurzel, sawdust, beans, peas, parsnips.

Tea is not now much adulterated.

*Cocoa*, besides containing theobroma (similar to caffein has nearly half its bulk composed of fat, and from 13 to 18 per cent. of albuminoid substances. It differs from tea and coffee, therefore, in being not only a nerve stimulant but also a nourishing article of diet. As the quantity of fat is rather large, various methods are adopted with the intention of remedying this. The best of these is one whereby some of the fat is removed. There should be at least 20 per cent. of cocoa butter left (Society Public Analysts). Other less successful methods consist in the addition of cereal grains, starches, sugar, carbonate of potash, etc.

**Condiments:**

*Mustard* is adulterated with turmeric (detected by microscope and liquor potassæ), wheat and barley, starch (microscope and iodine), and linseed (microscope); clay, plaster of Paris, and cayenne are sometimes added.

*Pepper* is adulterated with ground rice, sand, palm-nut powder, or 'poivrette,' wheat, and pea-flour, rape or linseed cake, cayenne and mustard husks, and the sweepings of pepper warehouses. These adulterations may be detected under the microscope. True pepper becomes intensely yellow when covered with strong HCl, so that foreign substances may be readily picked out.

Poivrette may be detected by moistening a little of the suspected pepper with 5·5 per cent. iodine solution in alcohol: in a few minutes the true pepper turns black, and the adulteration a bright yellow colour. The smallest trace of olive-stone powder may be seen by this means under low power.

*Vinegar* contains from 3 to 5 per cent. of acid calculated as glacial acetic acid, but unfortunately for dietetic purposes $\frac{1}{1000}$ part by weight of sulphuric acid is allowed to be added to vinegar in this country. The specific gravity of white wine vinegar varies from 1·015 to 1·022, malt vinegar from 1·016 to 1·019. If the specific gravity be low, and the acidity high, an excess of sulphuric acid has probably been added. Sodium carbonate or ammonia gives a purplish precipitate in *wine* vinegar, but not in *malt* vinegar.

*Pickles and preserved vegetables* are sometimes coloured with copper, but its place is now taken to a great extent by chlorophyll and other innocuous vegetable colouring-matters.

In purchasing samples under the Sale of Food and Drugs

Acts, 1875 and 1879, sufficient must be obtained for subdivision into three parts, one to be kept by the vendor, one to be analyzed, and one to be kept for future comparison.

## Exercise.

The regular action of the voluntary muscles, which is known as exercise, is necessary for the maintenance of good health. Without it the involuntary muscles, especially the heart and other organs, are much interfered with in the performance of their functions.

Effects of a proper amount of exercise : The oxidation of carbon is increased, chiefly in the muscles, and it is eliminated with an increased amount of watery vapour from the lungs. The circulation becomes more rapid, and greater pressure is produced on the vessels, hence there is a quicker removal of effete matters, and a more rapid renewal of tissue. Oxygen is necessary for muscular exertion, and, as its absorption is dependent on the amount and action of the nitrogenous structures of the body, more nitrogenous food is required with increased muscular work, else the growing muscles will rob other parts of the body (Pettenkofer and Voit's observations). For every additional foot-ton of visible work, 1 grain of nitrogen should be added to the food.

It is believed that during periods of rest oxygen is stored up in the muscles, and it is from this source that the greatest amount is drawn during action.

*Excessive or misdirected exercise* may lead to pulmonary congestion and hæmoptysis ; to cardiac rupture, palpitation, hypertrophy, and occasional valvular disease, injuries to blood-vessels, and to exhaustion of the muscular system ; this latter is due to the accumulation in the muscles of the products of their own action, especially paralactic acid, and to exhaustion of the supply of oxygen.

*Deficient exercise* favours spinal curvature, tubercular disease of the lungs, cardiac debility, dilatation and fatty degeneration ; lessens the appetite, enfeebles the digestive power, and produces congested conditions of the abdominal organs ; the nervous system becomes morbidly excitable ; it appears to lead in two or three generations to degenerate mental formation.

*Amount of exercise.*—To enable comparisons to be made between different kinds of exercise the 'foot-ton,' or 'foot-pound,' has been adopted as a unit whereby to express the amount of work done. One hundred foot-tons means that 100 tons are lifted 1 foot in a certain time. Sometimes pounds are used instead of tons, and in France it is expressed as so many kilogrammes lifted 1 metre.

Three hundred foot-tons is an average day's work for a healthy, strong adult; 400 foot-tons is a hard day's work. The internal work of the heart and muscles of respiration is equal to about 260 foot-tons, that for the heart varying from 122 to 277, and for respiration being about 11 foot-tons in 24 hours.

In calculating the work done by walking or climbing exercise, the following formula is employed:

$$\frac{(W + W^1) \times D}{20 \times 2{,}240} = \text{foot-tons.}$$

W is the weight of the person; $W^1$ is the weight carried; D is the distance walked in *feet;* 20 is the coefficient of traction, and is obtained from calculations showing that walking on a level surface at the rate of 3 miles an hour is equivalent to raising one-twentieth part of the weight of the body, etc., through the distance walked; 2,240 is the number of pounds in a ton. To get the distance in feet, multiply 5,280 by the number of miles walked. Three miles an hour appears to be the rate at which the greatest amount of work can be done at the least expenditure of energy. Work becomes heavier and more exhausting if done in a shorter time—that is to say, velocity is gained at a disproportionately increased expense of the amount of work. (See Appendix.)

From a consideration of the effects of exercise on the body, Parkes has deduced the following rules:

1. During exercise there must be no impediment to the freest play of the chest and respiratory muscles, else the removal of $CO_2$ will be checked. When breathing becomes laborious, with sighing, rest is necessary.
2. Food containing carbon and nitrogen must be increased with extra work. Carbon is best given in the form of fat.
3. Alcohol lessens the excretion of pulmonary $CO_2$, and deadens the action of the nerves of volition and hence prevents great or continued exertion.

4. As excretion of $CO_2$ is increased, a large amount of pure air is required; in covered buildings ventilation must be carried out to the greatest possible extent.
5. In commencing unaccustomed exercise, the action of the heart must be closely watched; the chief object of special 'training' is to get a concordant action established between the heart and the blood-vessels.
6. The skin should be kept extremely clean; during exertion it may be thinly clothed, but immediately after, or in the intervals of exertion, it should be covered sufficiently well with flannels to prevent the least feeling of coolness of the surface. The evaporation from the skin is nearly doubled, and the temperature is kept normal thereby. Any interference with it causes languor; and as it continues after exertion ceases, there is great danger of chill if extra clothing is not applied. After active exercise a good bath is useful to remove sweat, chloride of sodium, fatty acids, etc., which accumulate on the skin.
7. Water is absolutely necessary during and after exercise: it is better to take small quantities frequently during exercise than a large amount afterwards, when it might be dangerous from its sudden cooling effect. The precaution may be taken of holding the cold water in the mouth for a short time before swallowing.
8. Exercise should be adapted to the physical constitution, and should develop the whole system, and not be confined to certain groups of muscles which after enlarging will, if over-exercised, commence to waste. The periods of life when extra exertion should be taken with caution are between the ages of 15 and 17, when the most rapid growth takes place, and later in life, when the arteries become atheromatous. The Swedish system (Ling's) of gymnastics is well fitted to properly develop all parts of the body; but, as already pointed out, exercise in a covered building, as in gymnasia, should never be allowed to supersede outdoor sports. Exercise should be systematic and regular, and never sudden and violent; it should not be taken directly after meals.

# CHAPTER VIII.

## COMMUNICABLE DISEASES.

THE nomenclature of this subject is not in a well-defined condition at the present time. The recent growth of the study of Bacteriology has led to the formation of new theories, but their application has not proceeded sufficiently far to allow of a proper classification. We are endeavouring, therefore, to fit in the new theories with the old names, some of which are changing the meanings they have hitherto had; thus the term *Zymotic*, which is used to describe communicable diseases generally, in consequence of their course presenting more or less resemblance to a process of fermentation, is also employed in a limited sense to designate those diseases which occur in epidemics. The term '*specific*,' again, while undoubtedly a good one to describe many of these affections which arise from a specific cause, cannot, as yet, be held to be sufficiently accurate to include all the whole class.

The Registrar-General, in his reports, now classifies most of the communicable diseases in six orders under the heading—

*Specific, Febrile*, or *Zymotic Diseases:*

1. Miasmatic diseases—Eruptive fevers, influenza, pertussis, epidemic pneumonia, etc.
2. Diarrhœal—Enteric, simple continued, cholera, dysentery, diarrhœa, etc.

These two orders include the diseases described by the Registrar-General as 'the seven principal diseases of the zymotic class.' They are: (1) Small-pox. (2) Measles. (3) Scarlet-fever. (4) Diphtheria. (5) Whooping-cough. (6) Diarrhœa. (7) Fever—typhus, enteric, and simple continued (Febricula).

3. Malarial diseases.
4. Zoögenous diseases include vaccinia, rabies, glanders, splenic fever.
5. Venereal diseases.
6. Septic diseases include erysipelas, pyæmia, septicæmia (puerperal and non-puerperal).

Tubercle, in its many manifestations, and leprosy, which are now regarded as communicable diseases, are included under constitutional diseases.

All the above are now attributed to the action of *pathogenic* members of the class of micro-organisms known as *schizomycetes*, a class which contains also other organisms, many of them beneficent and useful in their action, such as in the destruction of dead animal and vegetable matter. Although contained in a sheath of cellulose, they belong functionally to the animal kingdom rather than to the vegetable, as they are occupied in breaking down the higher and more complex bodies into simpler ones.

In addition there are two other classes of micro-organisms connected with disease, the saccharo-mycetes or yeasts, and the moulds.

The schizomycetes are divided into several classes according to their shape. Thus there are :

*Cocci*, round and oval ; they increase by fission, but sometimes the separation is not complete, and a *diplococcus* is formed, as in pneumonia.

*Staphylococcus* is a group of cocci, of which an example is seen in the process of suppuration. When they occur in groups of four or more multiples thereof, the name *Sarcina* is applied. Other subdivisions are formed by adding the name of the disease with which they may be connected as M. scarlatinæ, or the name of a colour when colouring matter is formed during growth, as the Staphylococci pyogenes aureus.

*Bacilli* are rod-shaped, and present various appearances. Some develop rapidly by fission, and appear in their young condition like cocci ; as with cocci, the bacilli may not separate after increase and then form chains, threads or filaments—*Leptothrix.*

*Vibrios* are curved, or comma-shaped, cylindrical bodies which divide, forming S-shaped *spirilla.* This last must not be confounded with the spirillum, which belongs to the flagellate protozoa (Klein).

Bacilli multiply by fission, but most of them (the bacilli of enteric fever and diphtheria are exceptions) have the power of producing seeds, or *spores*, in their interior under certain conditions, these are : free access of air, proper temperature, and the presence of sufficient moisture. When the bacillus dies, the spores are set free.

Spores (like other seeds) have greater powers of vitality than the full-grown bacilli ; hence it is more difficult to prevent the spread of diseases due to spore-bearing bacilli by disinfectants, etc., than of diseases in which the microbes are non-spore-bearing. The vitality of many of the spores is so great that if circumstances favourable for immediate growth are not present, they will survive for very long periods ; outbreaks of diseases which seem spontaneous in their origin may be thus explained : thus no coccus or bacillus can survive a temperature above 65° C. (149° F.), while some spores are not killed by being raised to boiling-point unless they are kept for some time at it. Dilute acids have little effect on them, and they even withstand drying, which is fatal to all other organisms.

The term 'bacteria' was at one time used to describe the shorter rod-forms, but it now includes the whole of the schizomycetes.

In order to be able to state definitely that any disease is due to the action of the microbe, it is necessary to fulfil certain conditions as formulated by Koch :

1. The microbe must be found in the body of the man or animal suffering from or dead of the disease.
2. The microbe must be isolated and cultivated in suitable media outside the body of the animal. The cultivations should be carried on through successive generations of the organism in order to insure its purity.
3. A pure cultivation, when introduced into the body of a suitable healthy animal, must produce the disease in question.
4. In the inoculated animal the same microbe must again be found.

For some diseases, as anthrax, relapsing fever, erysipelas, pyæmia, it has been possible to fulfil these four conditions, but owing to the difficulty of fulfilling the third of Koch's conditions, the connection between cholera, scarlatina, diphtheria, enteric fever, and some other diseases, and the microbes attributed to them, has not been established. In other diseases, as small-pox, measles, and whooping-cough, no microbe has yet been identified.

*The cultivation of microbes.*—In the examination of air, water, and the fluids and tissues of the body, many kinds of microbes may be seen under the microscope, but it is possible to distinguish them from one another only by comparing their reactions to staining fluids and their appearance and mode of growth in certain media. The media which are used are both solid and fluid ; potatoes, peptone-gelatine, agar-agar (Japan isinglass), bread-paste, chicken-broth, milk, blood serum, urine, various chemical solutions, most of which contain sugar and phosphates. Germs grow in nutrient jellies in a manner varying with the way in which they are planted, the usual methods in tubes are surface, depth, and streak cultivations. Gelatine jelly is used when the required temperature at which the tubes have to be kept is under 25° C. (77° F.), at which point it liquefies ; agar-agar liquefies at 35° C. (95° F.). These media, as well as all apparatus with which either the microbes or the media come in contact, must be thoroughly sterilized, so that the cultivations which are made may be 'pure,' *i.e.*, unmixed with stray microbes.

It is found that some organisms grow better in one kind of soil, others in another. Thus pathogenic germs grow best in an alkaline medium, putrefactive in an acid one ; and at least twelve pathogenic forms will not grow in nutrient animal jelly (Klein) : while many organisms can obtain nitrogen from simple bodies, as ammonia and air, pathogenic bacteria require very complex nitrogenous substances, like albumen. It is not every acid, however, which interferes with the growth of pathogenic germs, as the acid surface of a potato affords a favourable nidus. Besides these points, their growth is influenced (Nasmyth) by temperature—(some may thrive just above freezing-point and others as high as 75° C. ; but these extremes are rare : from 16° to 42° C. is the usual range)—by the presence of mineral matter (amount and kind), and by the presence or absence of oxygen (ærobic or anærobic).

Some microbes can exist either with or without free access of air. Anthrax forms spores only when growing ærobically, while the microbes of tetanus and malignant œdema cannot grow at all if exposed to the air. The consumption of oxygen from the air is accompanied in some bacilli by active movement in the fluid in which they are growing; the motion, which may be of a serpentine description, as in enteric fever bacillus, or in a circle (as in hay infusion), or simply backwards and forwards, is due to the bacilli being provided with cilia or flagellæ. When there is an insufficient supply of air in the fluid, the movements cease and the bacilli crowd to the surface, forming a pellicle.

How do microbes act upon the soil upon which they grow? Recent experiments by Dr. A. McFadyen, as detailed by Dr. Lauder Brunton in the 1889 Croonian Lectures (which are worth careful study), show that, like more highly-developed bodies, those organisms connected with disease secrete a ferment or enzyme, which can be isolated, and which will continue to act after the microbes have been destroyed. He has also demonstrated that some bacteria can adapt themselves in a measure to the soil on which they grow, and produce such a ferment as will act upon the particular soil. It appears that a temperature which may destroy the microbes themselves, does not stop the activity of the ferment which they have formed. These ferments may produce toxic products resembling alkaloids, and not affected by heat. In this way may be explained those cases of poisoning which have happened after eating pies, hams, or other cold meats which have been cooked some little time before eating; but it is not unlikely that as such cases occur but comparatively rarely, the dangerous poisons are produced by the action of more than one kind of bacteria. Dr. Brunton suggests that this might happen when the dangerous meat is got from a diseased animal, the microbes already in its tissues combining their action with that of ordinary putrefactive bacilli.

These poisons are known as *Ptomaïnes* when formed by the decomposition of albumen by the microbes of putrefaction in the dead body; the more poisonous bases produced by pathogenic germs, Brieger has named *Toxines;* certain other bodies have been found as products of ferments, as in anthrax, which are neither alkaloids, albumen, nor peptones, these have been named 'albumoses' (toxic albumoses exist in snake poison), while those formed in the healthy living body by the breaking down of albuminous matter in the course of functional activity are called *Leucomaïnes.* 'Fatigue-fever' may be explained by the production of leucomaïnes being more rapid than the excretory organs of the body can keep up with ; a similar explanation may also serve for uræmia. Other results of the action of microbes we have seen in the process of nitrification ; and in the purification of rivers, etc. Some products have colour, and one micro-organism, not a putrefactive one, produces phosphorescence on vegetable and animal matter, and this product acts fatally on living animals if communicated to them.

Microbes, in order to produce disease, must obtain admission for themselves or their products to the body ; this is done in several ways ; some (such as those of syphilis, glanders, rabies, and vaccinia) enter only by direct inoculation, others (those of pyæmia and erysipelas) may also enter through a surface lesion ; some (those of influenza and measles) are air-borne, and enter by the respiratory mucous membrane ; others again (such as those of cholera, dysentery, and diarrhœa) may enter with food or water as well as by the air, and act primarily on the gastro-intestinal tract ; but it is not improbable that, under favourable conditions, all these diseases might be produced by inoculation (Bristowe). It is not always, however, that when bacteria obtain admission to the system that disease is produced. The explanation of this is to be found (1) in the insusceptibility of the body ; and (2) in the virulence of the microbe.

1. *Insusceptibility* is a condition which is due to the absence of a proper soil in which the microbes can grow. It is believed that epithelial cells, and perhaps blood corpuscles, have normally the power to resist the attacks of bacteria ; a lowered vitality of the body either hereditary or acquired, would, therefore, constitute a 'predisposition' to infectious disease. As age advances this power of the cells probably increases, so that the susceptibility is greatest in infancy and childhood (see statistics under scarlet fever). Another important cause of insusceptibility to some diseases is the (in a measure) protective influence of a previous attack. In the cultivation of micro-organisms in artificial media it has been found that the presence or absence of very minute quantities of certain salts was essential for growth ; this suggests that the first attack of a disease may use up some essential body which may not be reproducible, or only so after a long

interval, or some product may be left behind which would be inimical to a second successful growth of the germ.

2. *The condition of the microbe.*—Pasteur has demonstrated the fact that it is possible to increase, diminish, and altogether destroy the virulence of pathogenic organisms. Thus, in regard to swine plague, if the microbe is passed through a series of pigeons it becomes more virulent in its action, while, after passing through a series of rabbits, the converse is the case, and it is no longer able to kill pigs (Watson Cheyne). Whether the relation of cow-pox to human variola is to be similarly explained is a question still to be decided. Exposure to the oxygen of the air also has the effect of mitigating the strength of the original virus.

Pasteur found that inoculation with attenuated virus would produce local mischief, with slight constitutional disturbance, which would, however, act as a preventive (for some time) against future attacks of the disease. Cattle have by this means been rendered insusceptible to splenic fever, even when inoculated subsequently with the germs of the disease in their most virulent form.

Pasteur has been able to apply this knowledge in the treatment of persons bitten by animals affected with rabies. The rationale of the method is as follows: The strength of the virus is increased by transmission through rabbits or guinea-pigs. The greater the potency the shorter is the stage of incubation, which can be ultimately reduced to seven or eight days. This potent rabbit virus on exposure to a dry atmosphere becomes gradually attenuated, but the shortness of the incubation period when it is inoculated is still maintained, hence Pasteur thinks that the seeming attenuation is due to the formation of some substance which tends to neutralize the poisonous properties. Inoculation with the mildest form before absolute inertness is reached has only a preventive influence against the effect of a virus a little less reduced than itself. As the normal incubative period of rabies in dogs and men extends over several weeks, time is given to perform a series of inoculations gradually increasing in potency, each one of which will be protective against the succeeding one, the last and strongest will then be protective against that produced by the infliction of the bite.

In very severe cases the 'intensive' method is adopted;

the inoculations are greater, and the more recent, and, therefore, stronger, virus is used at an early period.

The death-rate in the protected is 1·36 per cent., as against 15 per cent. in the unprotected. This small mortality in the protected might be still further reduced if treatment could always be begun immediately after the injury. Of those who died while under treatment, nearly all developed the disease within a fortnight of the injury. For further information, Klein's 'Micro-Organisms,' Bristowe's 'Medicine,' chapter on 'Specific Febrile Diseases,' and a paper on rabies by Victor Horsley, in 'The Transactions of the Epidemiological Society,' may be consulted.

The terms *Endemic* and *Epidemic* are used in connection with preventible diseases, the former to imply that the disease is restricted within certain areas, and depends on local or localized causes, and has a tendency to persist in the district; the latter to describe a disease which suddenly appears and spreads widely and rapidly, but its prevalence is usually of limited duration. The two conditions, however, may pass into one another, *e.g.*, plague, yellow fever.

The term *Sporadic* is applied to diseases which occur in isolated cases, and appear sometimes as if of spontaneous origin, as typhus fever. Such cases are to be explained either by the sudden development of spores which have been waiting for a favourable set of circumstances, or, possibly, it may be that those conditions of overcrowding and filth may so aggravate the virulence of some organism (existing usually in the body without danger), that absorption of its products occurs and produces the symptoms known as typhus fever.

*Endogenic* implies that the contagion exists only within the body of an animal, as in hydrophobia, while the term

*Ectogenic* is used when the contagium can live outside the body; as examples, cholera in India and anthrax in the South of France and in Austria may be quoted. There the contagium thrives in the soil.

In this country these diseases are mostly only endogenic, but under favourable conditions they may sometimes be found growing out of the body.

*Action of the microbes in the body.*—As already mentioned, bacteria may enter the system and produce their effects therein, or they may remain, like tetanus and diphtheria, at the seat of inoculation, and send their poison only into the body ; or the organisms themselves may not be pathogenic, but their products may have toxic powers on absorption into the body, as in septic intoxication (sapræmia) and in meat-poisoning. The symptoms which follow are generally divided into stages thus—there is, for a longer or shorter time, a period of quiescence, latency, or *incubation ;* the period of *invasion* which follows is characterized by increased temperature, rigors, etc. When the distinctive features of the disease appear the stage of *advance* or *eruption* has begun ; these special features appear to be due to the fact that, after undergoing development in the invasion stage, the microbes and their products tend to accumulate in particular organs, as in the throat, bowels, nervous system, skin, etc. From these parts they are discharged from the body ready to propagate the disease, and they ultimately die out from causes unknown, producing the stage called *decline*, *defervescence*, or *resolution*, suddenly (crisis), or slowly (lysis). Various theories are suggested to explain why the microbes tend so often to die out in each case, as that the high temperature of the body kills them, or that the multiplication of the poison interferes with their growth. *Convalescence* is the period in which the body gets rid of the effete products, and restoration of the various functions is re-established. *Sequelæ*, however, sometimes occur after the disease appears to have been cured ; these are probably due to the action on the tissues of poisonous products which have not been eliminated or destroyed—perhaps on account of their late production. *Death*, however, may occur before a disease has run its course.

It is unnecessary here to describe the history and course of communicable diseases, as these, with their geographical distribution, have been or can be acquired from text-books and experience. Attention, however, will be called to certain points, especially in connection with differential diagnosis, as mistakes are sometimes made even by experienced men. Dr. Russell, of Glasgow, reports that 13½ per cent. of the patients sent to the fever hospital are sent with a wrong diagnosis ; diagnosis in a hospital is, however, a much easier thing than in a dark one-roomed house with the patient in such a state of uncleanness that the skin cannot be properly seen until it has been washed. The following table has been drawn up to exhibit the incubation stage of various diseases and the time that isolation is necessary. The figures are taken from a large number of observers, those relating to the incubation stage being the longest, shortest, and usual length of that period.

| Name of Disease. | Length of Incubation Period. | Usually. | Infection lasts. |
|---|---|---|---|
| Typhus ... | 1 to 21 days ... | 9 days ... | 3 to 4 weeks. |
| Enteric ... | 1 to 28 days ... | 15 days ... | 4 to 8 weeks, till diarrhœa ceases. |
| Relapsing ... | 4 to 10 days ... | 6 days ... | Until relapses cease. |
| Cholera ... | hours to 10 days | under 72 hours ... | Throughout attack; greatest during height of disease. |
| Yellow ... | hours to 15 days | few hours | |
| Scarlatina ... | hours to 7 days | 2 days ... | 8 weeks; end of desquamation. |
| Measles ... | 7 to 14 days ... | 12 days ... | 3 to 4 weeks; end of desquamation. |
| Rötheln .. | 4 to 21 days ... | 15 days .. | 2 to 3 weeks. |
| Small-pox ... | 5 to 14 days ... | 12 days ... | 3 to 6 weeks; until every scab has fallen off. |
| Chicken-pox | 4 to 18 (27) days | 10 days ... | 4 weeks; until every scab has fallen off. |
| Diphtheria ... | 2 to 12 days ... | 5 days ... | 3 to 8 weeks; until all discharges have ceased. |
| Influenza ... | 2 to 7 days ... | | (?) 14 to 21 days. |
| Whooping-cough ... | 7 to 21 days ... | 14 days ... | 6 weeks or longer. |
| Contagious Pneumonia | 1 to 20 days ... | 6 days | |
| Mumps ... | 4 to 24 days ... | 18 days ... | 3 to 4 weeks. |
| Erysipelas ... | 1 to 8 days ... | 4 days ... | Until end of desquamation. |
| Puerperal Fever ... | 2 to 6 days | | |
| Rabies ... ... | 6 days to 2 years | 6 weeks ... | Disease usually develops within 4 months. |

**Typhus Fever.**—Long-continued overcrowding, with defective ventilation and personal filth, are the conditions which favour the outbreak of this disease, which, beginning among the poor, may spread throughout all classes of a community. It is important that the early cases be recognised and promptly isolated in large, airy rooms; by this means the poison which proceeds from the lungs and skin, and is very potent under appropriate conditions, is rapidly destroyed by diffusion through the atmosphere.

Typhus may be mistaken for enteric fever, measles, meningitis, and delirium tremens.

It is distinguished from enteric by the absence of diarrhœa and the characteristic spots, and by the character of the temperature chart.

The symptoms which serve to distinguish typhus from the other diseases are:

| *Typhus.* | *Measles.* |
|---|---|
| No early symptoms. | Catarrh of air passages. |
| Not confined to children. | Confined to children. |
| Adults first, children after. | |
| Character of eruption. | Character of eruption. |
| Time of development. | Time of development. |

| *Typhus (in advanced stage)* | *Intercranial inflammation.* |
|---|---|
| Sensibility blunted. | Sensibility acute. |
| Headache only early. | Headache throughout. |
| Headache and delirium do not occur together. | Headache and delirium generally go together. |
| Pulse more feeble. | |
| More muscular tremulousness. | |

*Typhus.* *Delirium tremens.*

History; condition of the skin and tongue; muscular tremulousness in both, early in delirium tremens, late in typhus.

During convalescence from pneumonia there may be a typhus-like rash, but it disappears without any further symptoms.

The destruction of unhealthy property, the carrying of great thoroughfares through the densest aggregations of houses and the opening up of breathing spaces enabling the air to have free movement, have almost eradicated typhus from many of our large towns. The average annual death-rate due to this disease is now only 0·02 per 1,000.

**Simple Continued Fever,** or **Febricula,** in a small proportion of the cases, is probably due to slight poisoning by leucomaïnes; the great number, however, are better described by the Registrar-General as *ill-defined fever*, and are really undiagnosed cases of typhus, acute tuberculosis, septicæmia, intermittent fever, pneumonia of a low type, and, sometimes, enteric fever. The returns of deaths ascribed to this cause show an almost annual decrease. The total number in London in 1888 was thirty-three.

**Relapsing or Famine Fever** (apparently identical with the synochia of a former century).—The spirillum obermeieri is believed to be the immediate cause of this disease, as it is found in the blood in large numbers during the relapses, but is absent (in spirillum form at least) in the periods of apparent convalescence. The predisposing causes are extreme want, depression, and intemperance. It occurs only as an epidemic; all ages are affected. It is more common in children than typhus is. One attack of relapsing fever does not confer immunity from subsequent attacks of this disease. According to Dr. Murchison only 4·75 per cent. of those attacked die.

**Epidemic Diarrhœa.**—Diarrhœa is a prominent symptom in different complaints, and is frequently due to the presence of some irritant in the intestinal canal. Children are especially liable to be attacked with diarrhœa when changes are made in regard to diet, as at the time of weaning, or when improper food is given; but in summer this tendency is so greatly increased (adults also being affected), that such names as epidemic, choleraic or infantile diarrhœa, summer or English cholera, have been given to it. While this disease prevails quite as much (if not more so) among adults as among young children, yet the mortality is almost exclusively confined to the latter, and equals one-tenth of all the other causes put together. In England and Wales the average annual death-rate at all ages is 0·8 per 1,000; under five years of age it is 5·7 per 1,000. While it is true that improper feeding of children, and putrefactive changes occur more rapidly in food in warm than in cold weather, and might be sufficient to set up diarrhœa; yet it is now believed to be chiefly due to bacteria, and it is probable that they act in this as well as in Asiatic cholera by producing poisons in the intestine. In Dr. Lauder Brunton's opinion, 'probably much of the diarrhœa which occurs, especially in children, after the use of milk, is due to the formation of tyrotoxin, or other more or less poisonous products by decomposition of the milk in the intestine itself;' and as milk appears to be an excellent breeding-ground for septic and other organisms, it is easy to explain the reason why infants, who are breast-fed, have a much greater chance of escaping diarrhœa than those who are fed by hand. That the risk of bacterial inoculation is practically small in the former is shown by statistics collected by Dr. Hope, of Liverpool. He found that in 463 deaths from diarrhœa of children under six months, only 23 had been fed from the breast alone. During the last ten years considerable attention has been given to this subject by Dr. Ballard, and in 1889 he presented his conclusions in a report to the Local Government Board. The following is the working hypothesis or provisional explanation which Dr. Ballard makes the basis of certain practical suggestions for the prevention of epidemic diarrhœa:

'That the essential cause of diarrhœa resides ordinarily in the superficial layers of the earth, where it is intimately associated with the life-processes of some micro-organism not yet detected, captured, or isolated.

'That the vital manifestations of such organism are dependent, among other things, perhaps principally, upon conditions of season, and on the presence of dead organic matter, which is its pabulum. That, on occasion, such micro-organism is capable of getting abroad from its primary habitat, the earth, and having become air-borne, obtains opportunity for fastening on non-living organic material, and of using such organic material both as nidus and as pabulum in undergoing various phases of its life-history.

'That in food, *inside* of as well as *outside* of the human body, such micro-organism finds, especially at certain seasons, nidus and pabulum convenient for its development, multiplication, or evolution.

'That from food, as also from the contained organic matter of particular soils, such micro-organism can manufacture, by the chemical changes wrought therein through certain of its life-processes, a substance which is a virulent chemical poison; and that this chemical substance is in the human body the material cause of epidemic diarrhœa.'

Certain factors have been noted as having an important bearing upon the development of diarrhœa, the chief of these being the nature and temperature of the soil.

1. Nature of the Soil.—A high mortality occurs on loose soils, such as those composed of sand, gravel, marl, or marl with clay, which are easily permeated by water and air, and especially when such soils are contaminated with organic animal matter. Excessive dryness or wetness of the soil is unfavourable to diarrhœa.

2. Temperature of the Soil.—The atmospheric temperature has very great influence; but it is exerted indirectly, as Dr. Ballard found that the mortality did not increase until the mean temperature recorded by an earth thermometer, at a depth of 4 feet from the surface, has attained to about 56° F.—no matter what the temperature previously attained by the atmosphere, or recorded by a thermometer at a depth of only 1 foot from the surface, may have been. The mortality rises and falls with the four-foot thermometer. It usually begins to rise rapidly in the middle of June, attains a maximum towards the beginning of August; the fall begins slowly in August, becomes more rapid in September, and recovers its ordinary rate by the end of October. The years 1887 and 1888 afford an illustration of the effects of temperature. In 1887 the mean temperature of the third quarter was 61° F., and the mortality from infantile diarrhœa was high, while in 1888 the mean temperature was 57·6° F., and the number of deaths less than half those in the previous year. Minor influence on the mortality is exerted by the amount of rainfall, rise or fall of ground-water, wind or comparative calm, and by elevation above sea-level, according to the way in which they hasten or retard the rise of temperature, or affect the wet or dry condition of the soil.

3. Density of population.

4. Density of buildings upon any given area.
5. Restricted circulation of air *about* or *within* dwellings.
6. Domestic darkness, and general dirtiness and fustiness of dwellings.
7. Emanations from sewers, cesspools, middens, privies, and dust-bins.
8. Filthy accumulations.
9. Polluted drinking water and food supplies, especially milk, and everything about a house which tends to lower health and vitality, exert a baneful influence, and should be remedied.

Dr. Ballard recommends subsoil drainage, concreted sites for dwellings, free ventilation, daily scavenging, proper drainage, and special precautions to protect the milk supplies from contamination, aerial or otherwise, both before and after it reaches the consumer.

**Asiatic Cholera** is seldom absent from Hindostan. It has been imported into this country on several occasions by travellers coming direct from infected places and by clothes which have been exposed to the poison; its usual method of distribution is through the agency of the drinking water, especially if that be impure. When introduced into temperate countries a few isolated cases appear in the autumn, and then the disease disappears, to become an epidemic in the ensuing summer; the conditions favourable for diarrhœa are also suitable for the production of the specific microbe of cholera. To the comma-shaped bacillus discovered by Koch has been attributed the causation of cholera; but Dr. Lauder Brunton thinks it probable that the symptoms are not caused by a poison formed by its action alone, as none of the poisons produced by pure cultivations of the bacillus have produced exactly the symptoms of cholera. Whatever the poison may be, it is chemical in its nature, and may act independently of the microbes which produce it; the symptoms of cholera are exactly those of muscarine poisoning. The comma-bacillus is to be found in the rice-water dejections which characterize the complaint; it probably develops in loose moist earth or in water.

**Enteric or Typhoid Fever.**—It was at one time believed that this disease might be produced by the use of water containing decomposing sewage, but conclusive evidence (such as the report by Dr. Ballard on an outbreak at

Nunney, 1872, quoted by the late Dr. Parkes) has been advanced, showing that the entrance of enteric evacuations is necessary before enteric fever results. Gaffkey and Eberth have isolated a bacillus from the fæculent discharges of enteric patients; and it appears that it is through its agency that the disease is disseminated. According to Brieger it produces a poison which he calls typhotoxine. In many particulars the same conditions which favour the development and spread of diarrhœa and cholera also obtain in connection with enteric fever. Soils impregnated with animal filth, cesspools, sewers improperly laid, seldom cleansed, and containing deposits for long periods, and water supplies contaminated with organic matter, furnish suitable localities for the development of the bacillus (this is one of the bacilli which do not produce spores); and it is *out of*, rather than *in* the human body, that the infectiveness of the poison is developed. This is shown by the rarity with which nurses, whose duties expose them to the influence of the poison in its recent state, acquire the disease, and by the rapidity and ease with which an epidemic is occasioned when the poison finds access to the water supply of a community.

That a certain temperature also is required in this, as in these other diseases, is shown by the prevalence of the complaint in the autumn months, when the deeper layers of the subsoil have become heated.

Pettenkofer's opinion is that the deaths from enteric fever are greatest when the level of the ground-water is lowest; but as the increase in the mortality frequently follows a rapid sinking of ground-water after an unusual rise, it is highly probable that the fluctuations of the ground-water merely serve to promote the growth of the enteric bacteria, by adding or removing moisture, and by influencing the temperature and composition of the ground-air. At the same time it may be possible that the movement of ground-water into or from impure soil may carry the germs of enteric fever into the drinking water, especially when derived from wells. Dr. Buchanan has pointed out that when the ground-water has been permanently lowered by drainage operations, that enteric fever has diminished, a result to which the introduction of pure water from a distance has also contributed. While the poison of enteric fever is usually conveyed tc the human body through the water supply, yet it sometimes finds entrance by being inhaled with the breath, as in the effluvia from cesspools, stopped drains, filthy closets, soil-pipes, ventilators ending near windows. Prof. Finkler, of Bonn, has lately given an account of a series of cases which spread only among those who had come into direct contact with patients or their linen. It is quite possible that clothes may be stained with the discharges which, becoming dry, give off the germs or spores into the air.

Milk is a common means of conveying the poison: it may be contaminated by the water used to dilute it, by the utensils in which it is contained being washed with such water, or by the poison being taken up from the air. Water also may absorb the poison, as when the cistern overflow-pipe is connected with the water-closet. The disease may also be spread by the internal use of ice and ice-creams, as researches by Bischoff, Froenkel, and Mitchell Prudden have shown that ice may contain large numbers of bacteria, the latter observer having succeeded in growing enteric germs after they had been frozen in ice 103 days.

It has been sought to prove a connection between diseases affecting cattle and human typhoid. The evidence advanced by Mr. W. Brown, of Carlisle (Annual Report, 1887), goes in this direction, so far as regards the specific enteritis of cows; mention has also been made (*Sanitary Record*, July, 1888) of five epidemics of enteric fever produced 'by the ingestion of the flesh (beef and veal) of diseased animals.' Swine-plague, however, bears no relation to human enteric; the patches of ulceration which occur in the intestines have no connection with lymphatic follicles.

Dr. Murchison's statistics show that the liability to contract enteric fever is about equal at all ages up to about twenty-five, and from that age onwards it rapidly and uniformly diminishes. Dr. Parsons has suggested (1888 Report, Local Government Board) that the cause of children and women being more affected than men in this particular outbreak was that children drank more water than adults, and women than men; usually, however, sex has no influence.

From 8 to 25 per cent. of the cases end fatally; that these figures are too high is possible, as many cases are so mild as not even to be recognised. The death-rate is less below the age of twenty than above it, is highest in patients about fifty, and almost *nil* in young children (London Fever Hospital).

The annual mortality is now 0·18 per 1,000 living, and statistics show that there has been a general tendency to decreased mortality during the last two decades, the average for the first being 0·35, and for the second 0·21 per 1,000.

*Differential diagnosis:*

The diseases with which enteric fever may be confused are: simple gastric catarrh, simple continued fever, acute tuberculosis, tubercular meningitis, typhus, scarlatina, measles, pneumonia and typhlitis.

In simple *gastric catarrh* the temperature chart should guide.

In simple *continued fever* there is an absence of the eruption, abdominal symptoms, and the characteristic temperature.

In *acute tuberculosis*, the above are also absent. The physical signs should be observed as to dulness on percussion of the apices of the lungs, as to auscultatory changes, and as to alteration in the rhythm of the breathing and cardiac action; in acute tuberculosis the breathing becomes more rapid relatively to the heart's action. In enteric there is often dulness at the base of the lungs.

| *Tubercular Meningitis* in children. | *Enteric Fever.* |
|---|---|
| Tongue—keeps moist, | yellow with red edges, and soon becomes dry. |
| Thirst—normal, | increased. |
| Vomiting—frequent, | rare. |
| Abdomen—retracted (often), | full. |
| Bowels—constipated, | loose. |
| Headache—severe, | not great. |
| Intolerance of light and squinting, | spots on skin. |

In regard to *typhus*, the points to be observed are the eruption, date of its appearance and duration, the abdominal symptoms and temperature chart.

*Scarlet fever.*—Sometimes in enteric a rash resembling that of scarlet fever comes out before the proper time for the appearance of the lenticular spots, but the condition of the throat, temperature, date, etc., should decide.

*Measles.*—In 1887 eight cases of measles and rötheln were admitted to the Western Fever Hospital, London, certified as enteric fever. If the rash be deferred, or if pneumonia or diarrhœa be present, the condition might be suggestive of enteric, the temperature, age, method of onset and surrounding circumstances should be examined.

*Pneumonia.*—Enteric fever has been mistaken for pneumonia (and *vice versâ*), when it has been a prominent part of the disease.

*Typhlitis and perityphlitis.*—History, onset, temperature and condition of bowels, etc., serve to distinguish.

As a farther guide in the diagnosis of typhoid may be mentioned the presence of the 'Diazo-reaction,' obtained by adding a mixture of sulphanilic acid, HCl, water, and sodium nitrite to urine. Karlinski states that Everth's bacillus may be detected in the urine at a very early stage.

Enteric fever possesses a number of synonyms as: typhoid, bilious or gastric fever, infantile remittent, abdominal typhus, worm fever, etc.

It is important to note in regard to these 'filth' diseases that the saprophytes contained in the soil have the power of destroying these pathogenic germs: probably it is when the soil is too wet or too dry the saprophytes themselves may be destroyed or weakened, so that the pathogenic germs acquire an ascendancy. As these saprophytes live only in the upper layers in the soil, organisms buried below would not be influenced by them.

**Diphtheria**, or **Membranous Croup**.—Dr. Roux, of the Pasteur Institute, has recently published the results of his researches into the mode of action of the microbe which was first associated with this disease by Klebs.

This bacillus develops *on* the mucous surfaces of the body, and on any wounded area of skin; it does not invade the tissues, and is incapable of multiplication subcutaneously; in its growth it produces a soluble toxic substance resembling the diastases in nature, and it is the absorption of this poison which produces the effects on the system, the later symptoms of paralysis being caused by a late development of the poison or by the penetration of the poison into nerve-cells.

Cultures of the bacillus have energetic toxic properties when the media are alkaline. The poison becomes innocuous after boiling, also after exposure to the air—slowly in the dark, rapidly in bright sunlight. These facts are suggestive as to the best methods to adopt for treatment and prevention of the disease. The spread of diphtheria is undoubtedly favoured by dampness, defective drainage, polluted water supply, *personal communication*, especially among school children; houses overcrowded and with impure air; accumulations of manure, etc., about a house; want of isolation and disinfection of clothing; by the milk supply. It seems probable that the lower animals may suffer from this disease and transmit it to human beings; among those suspected are pigeons, rabbits, chickens, turkeys, cattle, dogs, and cats (*vide* Local Government Board Reports for 1888, by Dr. Bruce Low and Mr. Spear). The latter observer, in pointing out that this disease is one peculiarly subject to hereditary predilections, suggests that intermarriage, which is common in some communities, may possibly be conducive to the development of this susceptibility.

The prevalence of this disease in the later months of the year may be explained on the hypothesis that the poison lies dormant in the sewers until called into activity by the stirring up of the sediment by the autumn rains (Parsons). This may possibly be one factor, especially coming after a season of heat and drought, for although the organism appears to be endogenic in its nature, yet as it can be conveyed by milk, water, and sewer-air, it may also be able to thrive outside the body.

The disease attacks all classes of the community, but children between the ages of two and ten years are specially liable; the mortality between those ages is also the greatest, that under five years being greater than that between five and ten years.

The conditions which favour the existence of diphtheria appear also to be suitable for scarlet fever and measles, as those diseases are frequently prevalent at the same time. It has even been suggested (by Mr. M. A. Adams, of Maidstone) that these diseases are in some measure interdependent, and that the germ of diphtheria in its growth may be influenced by the presence of the excretions of the organisms of scarlet fever or measles, just as acetous, lactic, or butyric ferment may follow upon, and be favoured by, a foregoing saccharine fermentation.

There appears to be no doubt that diphtheria may occur in a minor form of illness difficult to recognise until it is communicated to others in an intensified degree. While it is possible that an apparently simple tonsillitis may be diphtheritic in its nature, follicular inflammation and ulceration of the tonsils may be mistaken for the more serious disease.

The mortality of the last three years has been much above the average of the previous ten ; this rise has taken place chiefly in the first and last quarters of the years. The annual average, which has been 0·14 per 1,000, has now risen to 0·17. In 1888 the first and last quarters had a death-rate of 0·20 and 0·21 respectively. In London the rise has been very great ; during 1889 the mortality has risen as high as 0·48 for September, the average of the third quarter giving 0·43 per 1,000.

**Epidemic Influenza.**—In every year, during changeable weather, cases of catarrhal affections of varying intensity are by no means uncommon, but influenza is a disease which comes only at irregular intervals, spreading rapidly from one country to another, and lasting in each district from six to eight months. It appears to have no relation to unsanitary conditions, and it prevails at the same time in countries on both sides of the globe quite irrespective of season.

Dr. Siefert, of Würzburg, claims to have discovered a micrococcus in the expectoration from all cases of influenza, and which is not existent in that from ordinary bronchitis. The rapidity of the spread of influenza points to the air as the medium by which the contagion is carried ; but it is also given off in the breath of affected persons, so that the disease may be carried from an infected district to one not so by visitors suffering from an attack : it is also possible that the contagium may be carried by means of letters in transit from one country to another.

No age or sex is free from liability ; and even horses and other domestic animals may suffer. The mortality is small, about two per cent., and is chiefly among the aged or those already suffering from cardiac or pulmonary troubles. This small mortality, however, adds considerably to the death-rate, as the disease attacks such a large number of people.

The incubation stage during the late epidemic appeared to last two days. It affected people in three different ways: in one form the respiratory tract was most affected; in another, gastric and intestinal catarrh was the principal feature; while a third form was characterized by severe muscular pains resembling rheumatism. All three forms were generally accompanied by much nervous depression and by high temperature.

Relapses were very apt to occur after apparent recovery if there was too early exposure to cold. In some cases an erythematous rash was present.

The only means to prevent its spread from individual cases is isolation and the use of aerial disinfectants in the rooms occupied. The local application of salicylic or boracic acid to the mucous membrane of the nose, and inhalations of eucalyptus oil, sanitas oil, terebene, etc., appear to have power to stop the development of the disease if used early.

A resemblance between influenza and dengue gave rise to the theory that the latter disease, which is endemic in many warm countries, had, like cholera, become epidemic; but this has been disposed of by Dr. Limarkis, who, living in Constantinople, has had ample opportunities of seeing both diseases, and who gives a series of differential symptoms. These, arranged in tabular form, are as follows:

| | *Dengue.* | *Influenza.* |
|---|---|---|
| Localization: | Hot countries. | All climates. |
| Duration of an epidemic: | Three to five months. | About one and a half months. |
| Spread: | Slowly, from small foci. | Rapidly, attacking large districts simultaneously. |
| Commencement of the disease: | Always sudden. | Almost always sudden. |
| Fever: | Always very high. | Not always very high. |
| Nervous system: | Prostration, pain in the head and limbs. | The same. |
| Larynx and trachea: | Seldom attacked. | Always attacked. |
| Dyspnœa: | Never. | Common. |

| | *Dengue.* | *Influenza.* |
|---|---|---|
| Gastric symptoms : | Always ; violent, persistent. | May be absent. |
| Eruption : | Always; beginning in the face, descending, erythematous, ending in desquamation. | Rare, regular. |
| Headache : | Sensation of external pressure ; iron hoop. | Violent, internal, often neuralgic pain. |
| Complications : | Rare ; of heart, liver, and kidneys. | Common ; bronchioles and lungs. |
| Convalescence : | Very slow. | Usually rapid. |
| Prognosis : | Always favourable. | Often occurs in malignant form. |
| Attacking animals : | Dogs, cats. | Horses. |

Still further proof that influenza is not a form of dengue modified by climate is the fact that the former occurs in hot countries in exactly the same form as in Northern Europe, and that the two diseases appeared in Constantinople, the one shortly after the other.

**Scarlet Fever** (Scarlatina).—The etiology of scarlet fever has been the subject of much discussion during the last four years. It is decided that the cause is due to an eminently contagious body, probably the strepto-coccus described by Klein ; that both man and the lower animals may be affected with it ; that the disease is spread by all matters passing from the bodies of those affected, but especially by those which come from the lungs, throat, nose, and skin ; that the contagium may be carried by the air unchanged through small distances, as through a house, without loss of power ; that it clings to clothes, and may retain its vitality over very long periods ; that milk is often the means by which scarlet fever is disseminated, and here the difficulty occurs and still waits solution, How does the poison get into the milk ? Until what is known as the Hendon inquiry (Local Government Board Report by Mr. Power, March, 1886) this question was answered, that particles of skin containing the poison fell into the milk and were conveyed to the consumer—and that is no doubt one way—but Mr. Power, in consequence of an epidemic springing up in North

London among persons supplied with milk from a dairy at Hendon, where certain of the cows were found to be suffering from small vesicles and ulcers on the udder and teats (now called the 'Hendon Disease'), started the theory that the milk of those cows produced scarlet fever in the human subject. Professor Klein found in them the same strepto-coccus as in scarlet fever, and calves fed on sub-cultures established from human scarlatina obtained the Hendon disease. It is, however, still a matter of doubt whether infected milk derives its infection directly from the diseased animal (in the same way as it would be in other secretions of the body) or indirectly from the hands of the milker by causing the poison to fall into the milk either from the inflamed teats or from his own desquamating cuticle. Each or all of the three methods is possible.

Scarlet fever is most prevalent in the autumn, the mortality rising highest in October and November. It adds on an average about 0·5 per 1,000 to the death-rate annually, but it is found that for about three years scarlatina is little prevalent, and then in the fourth year it will become epidemic ; this is explained by the fact that during the first year of life the liability to this disease is almost nil ; that it increases up to the fifth year, after which the susceptibility diminishes rapidly with every year of age, so that as many children are attacked at one time in large towns, for the next few years after an epidemic the community is in a great measure protected. It is worthy of note that the rate of liability to the disease does not quite correspond with that of the mortality from it. The death-rate is highest in young children, averaging 3·5 per 1,000 under five years ; it then diminishes to about a third between five and ten years, and continues to fall to the end of the twenty-fifth year, after which it increases to a small extent. It has been sought to show that it is desirable that people should have scarlet fever when young, as the mortality is less between ten and thirty than over the latter age, but this argument is founded on the fallacy that everyone must, sooner or later, suffer from scarlatina, which is not the case, as Dr. Whitelegge has well pointed out that every year of escape from it renders the person less and less susceptible until almost entire insusceptibility is reached.

Another point of divergence between the susceptibility and mortality rates is in regard to sex, the female being the more susceptible, but the males furnishing more deaths proportionately.

*Differential diagnosis:* Thirteen cases of *measles* or *rötheln*, certified as scarlet fever, were admitted into one of the London fever hospitals in 1887. Accurate observation should prevent such mistakes; during the early stage the temperature, premonitory symptoms, and the early rash of scarlatina should decide. As to the eruption, the date of appearance, situation, colour, and mode of grouping will guide. If the disease is seen late in the illness the character of the desquamation should be observed. Small-pox and scarlet fever have been confused, but the presence of sore throat and absence of pain in the back should assist at first, while the eruption, history of exposure, and subsequent desquamation should remove all doubts.

**Measles** is confined in its attacks chiefly to children, and so, as with scarlet fever, becomes epidemic every third or fourth year; but no age is altogether protected, as is evidenced by an epidemic which broke out in the Faroe Islands in 1846. The disease, which had not been known in the island since 1781, was introduced by a sailor, and all but a few old people who had suffered from it at the earlier date were attacked. This is one of the diseases which raises largely the infantile death-rate; at all ages the mortality is about 0·4 per 1,000, but under five years it amounts to 2·8 per 1,000 living. It has been suggested that of late years the type of the disease has altered, and that it has become a more serious disease. The cause of death is due chiefly to the irritation of the mucous membranes, producing laryngitis, bronchitis, diarrhœa, etc., but these are mainly developed among the children of the ignorant and careless; as soon as the rash has disappeared the child is allowed to run about out of doors, and, as the disease is most prevalent in the winter and spring, it proves to be then most fatal also. It is believed to be infectious during the stage of invasion. The contagium is given off from the skin and breath, and clings persistently to clothes; hence the disease is spread more by contact of one child with another than by the air.

**Rötheln,** rubeola, or German measles, while resembling both measles and scarlatina in its symptoms, yet is incapable of inducing either of these diseases or of protecting from a subsequent attack of either, nor is a patient who has had both protected from this. Measles or rötheln may be confused with enteric fever, scarlatina, syphilis, the rash produced by gastric derangement, the rash induced by the use of drugs, such as cubebs, copaiba, iodide of potass, sulphate of quinia, and with the simple dermatitis known as erythema roseola.

**Whooping-cough** (pertussis), another disease affecting chiefly infants, bulks largely in the Registrar-General's reports, the death-rate at all ages being 0·5 per 1,000 living, and 3·6 under five years of age. Like measles and scarlatina, with which it is often associated, it occurs in epidemics every few years. It is most prevalent and most fatal in spring. The infection is given off in the breath, but is also carried by the clothes. It gains admission to the body by the air-passages, generally beginning in the nose, so that it may readily be mistaken for ordinary catarrh. The treatment by aerial disinfection of the rooms occupied, and the insufflation of the nose with powdered boracic acid, will in many cases stop the development and prevent the spread of the disease.

**Epidemic pneumonia.**—Although Fraenkel discovered a diplococcus, which he claims to be the microbe of ordinary pneumonia, yet this is a disease which rarely appears to be infectious ; but cases exhibiting great virulence from time to time occur. In some fatal cases in an epidemic at Middlesborough, Professor Klein found, besides ordinary pyogenic organisms, a bacillus which he regards as specific. The poison spreads by the air, chiefly from the breath of patients, and is specially favoured by insanitary conditions.

**Variola, Small-pox,** exists in this country in what may be called two forms, which require to be distinguished, viz., the natural and the modified.

*Natural* or *unmodified* small-pox is now rare. It affected especially children under five years of age in the same way as scarlatina, measles, etc., and like them also recurred in epidemic form every three years, and as all ages and both sexes were liable to it, very few escaped. The mortality was very high, more than one-third of those who suffered died, while many who survived lost their eye-sight and hearing, or were disfigured in a way we have very little experience of nowadays.

*Modified* small-pox, or varioloid, occurs in those :

(1) Who have had the disease before.
(2) Who have been inoculated with the poison.
(3) Who have been vaccinated.

The fatality in inoculated cases was only 3 per 1,000 cases, but the practice was so instrumental in spreading the disease throughout the country that it had to be prohibited.

Small-pox, which has been modified by previous vaccinations, does not attack children as a rule, and when it does the mortality is 85 per cent. less than it was in unmodified small-pox. It is chiefly persons over fifteen years of age that are now attacked.

The symptoms in the modified disease are similar to ordinary small-pox up to the eruptive stage, but after that it aborts. Small-pox appears to recur about once in ten years, being most prevalent during the first six months of the year, reaching a maximum towards the end of May.

*Diagnosis.*—Cases mistaken for small-pox are sent in large numbers to the London hospitals; no less than one-third of the cases sent in one year (1886) were found to be other complaints. It is important that this disease should be properly recognised at an early stage, as affected persons may go about spreading the disease if unrecognised ; and, on the other hand, persons supposed to have it and sent into hospital, are exposed to the infection, and if such persons are suffering from some other infectious malady, this new disease may be introduced among those recovering from small-pox and ill-fitted to resist a new infection. The diseases which have been wrongly diagnosed have been varicella, scarlatina, syphilis, measles, eczema, ecthyma.

*Varicella* has sometimes been mistaken for varioloid, as in an epidemic in South Africa some few years ago. The distinctive features are :

| *Chicken-Pox.* | *Small-Pox.* |
| --- | --- |
| Initiatory fever—slight. | Well marked. |
| Eruption—in 24 hours. | On third day or later. |
| ,, is scattered. | Is in groups. |
| ,, all over body. | Most marked on face where it may begin. |
| ,, often well marked between scapulæ. | |
| ,, spot is not hard. | Feels like shot. |
| Vesicle formation in a few hours. | Delayed. |
| ,, little areolæ or umbilication. | Well marked, even in modified. |

*Syphilis* may be mistaken for small-pox in the early stage of eruption ; many of such mistakes have resulted from the person suffering from a feverish catarrh at the same time, and concealing the truth as to having had a chancre, the date of the appearance of the rash, pains in the back, etc., either wilfully or from a want of knowledge of the language, as in the case of foreign sailors.

Careful inquiry into the history and probable exposure to the poison, with the state of the bodily temperature, etc., should assist in deciding definitely.

The *Infection* of small-pox exists throughout the whole course of the disease, and is contained in all that leaves the body ; it remains effective for long periods, and may be conveyed by clothing. It may also be transmitted by dead bodies, bedding, books, etc. It is sometimes imported in bales of rags to the workers at paper and shoddy mills. The opinions advanced by Mr. Power in his 'Report on the Incidence of Small-pox in the Fulham District,' should be known by those whose advice may be sought as to the site for such a hospital.

He concluded that small-pox appeared in the neighbourhood of the hospital as soon as cases were sent in.

The percentage of cases was smaller in houses as the distance from the hospital increased.

Houses in the main thoroughfares were not more affected than others, showing that there was no appreciable effect produced by the passing of the ambulances.

There was a marked relation between the varying use of the hospital and the outbreak in the district.

Its appearance was not delayed till the hospital was full, but began with the *first* admissions.

The incidence of the disease was greater and extended to a greater distance in the S.E. direction, due, no doubt, to the prevalence of N.W. winds at the time.

The *special area* through which infection may spread is a circle, with a radius of one mile from the hospital.

The theory of the aërial diffusion of small-pox is not agreed in by other observers (Thorne Thorne, Dudfield, Barry, etc.) who attribute its spread rather to personal communication from imperfect isolation, and to the movement to and from hospitals to convalescent camps, etc., of slight cases, or of convalescents in the most infective stages of the disease.

**Vaccinia, Cow-pox.**—What is it? Is it a special disease of cows, or is it a modification of what is known in man as small-pox? Many authorities, like Simon, Hutchinson, Bristowe, etc., hold to the latter view, and those who have read the previous articles upon the way micro-organisms behave when grown upon different soils and in different animals, will feel that it is only a matter of time until it will be possible to prove that the passage of variolous matter through cows results in the production of an attenuated and protective virus, as clearly as has already been done in regard to anthrax, etc. Other arguments which favour this view are to be found in:

The protection it confers against small-pox.

The similarity between the appearance and progress of the inoculated pocks; the same latent stage before the appearance of the general disease, and the production on the eighth day of feverishness and other symptoms of the invasive stage, followed sometimes even by a roseolous rash, spreading over the vaccinated limb and thence to other parts of the body. The rash may sometimes be vesicular and papular.

The relation between epidemics of small-pox and cow-pox.

The seat in which cow-pox exists, the udder and teat being the situations most likely to exhibit signs of inoculation if conveyed by man.

The fact that cow-pox, when experimentally inoculated from cow to cow, tends to die out.

Crookshank holds strongly to the opinion that cow-pox and small-pox are specifically distinct.

The official memoranda issued by the Local Government Board on vaccination and re-vaccination should be procured, and the instructions for the proper performance of the operation carefully studied. Upon the care and efficiency with which vaccination is performed depends, to a great extent, the protection against small-pox, which is the one object to be secured. There is a strong feeling among many that the outcry against vaccination is in part due to the fact that it is not so thoroughly carried out as it ought to be, and thus persons supposed to be 'successfully' vaccinated and protected against small-pox contract that disease.

On re-vaccination, if the persons be again fully susceptible, the local effect appears earlier than after primary vaccination, and the local and constitutional symptoms are more severe. If the susceptibility be less, then the results will be proportionately less. But the results also depend on the health of the person operated upon, and the age of the pock from which the lymph is taken.

The practice of vaccination, while carrying with it numerous benefits, has also some disadvantages which demand attention.

Under the heading of small-pox it was stated that certain changes had taken place as to the ages of the persons affected, and that epidemics were not so numerous or so fatal. These are changes which have not been exhibited by any other zymotic disease ; and it is held that they are due to vaccination. The following statistics, presented by Dr. Ogle to the commission now inquiring into the subject, bear out this claim. The death-rate from small-pox was :

| Per million. | | | |
|---|---|---|---|
| 408 | in 1838 to 1853 ; | vaccination | being optional. |
| 223 | in 1854 to 1871 ; | „ | compulsory, but not enforced. |
| 114 | in 1872 to 1887 ; | „ | enforced. |

There was an epidemic in 1838, also in 1871, in which year also additional machinery was provided for carrying out the Act.

The only other factor which could produce a change in the death-rate would be improved sanitation, but while the general death-rate has declined 9 per cent., that of small-pox decreased 72 per cent.; this decrease, moreover, has not been equally shared by people at all ages as it should be if due to improved sanitation solely, for in

| | | | | | |
|---|---|---|---|---|---|
| the first 5 years of life | the mortality | has fallen | 85 | per cent. |
| from 5 to 10 years | ,, | ,, | ,, | 64 | ,, |
| from 10 to 15 years | ,, | ,, | ,, | 27 | ,, |

and over that age the mortality has actually increased. It was at one time believed that vaccination in infancy conferred immunity from small-pox for the whole period of life, but it is now known that it does not do so in all cases. and that in some the protective effect becomes exhausted in from ten to fifteen or more years; the above statistics show this conclusively. It is therefore that protection may be still further continued throughout life, that re-vaccination is recommended at twelve years of age. The protective value of this practice is shown by the experience of nations differing in their small-pox death-rates as their laws for re-vaccination differ; good examples are afforded by the neighbouring states of Germany and Austria, in the former re-vaccination being enforced. In Prussia, since 1874, when both vaccination and re-vaccination became compulsory, the small-pox death-rate has fallen from 0·24 per 1,000 to 0·02 per 1,000, while in the army there has not been a death from small-pox since that date. Additional evidence of the immunity conferred by re-vaccination is given in our own country —in the case of the London permanent postal officials, in the case of nurses in small-pox hospitals; while the late Sheffield epidemic died out only when the unvaccinated population became exhausted.

It is not held that a person who has been vaccinated and re-vaccinated is absolutely certain not to be affected by small-pox, for 221 cases at Sheffield occurred among persons who had been re-vaccinated, but such cases might be reduced almost to nil if people did not defer re-vaccination until there is an actual alarm of small-pox, when most probably stored lymph has to be used, and perhaps no immunity conferred by its performance. Even in primary vaccination there are very grave doubts that the full measure of protection that is possible is given, and hence vaccination suffers much unmerited disparagement when the so-called 'successfully' vaccinated person contracts small-pox. The reason for coming to this conclusion is that sufficient importance is not attached to the way in which vaccination is performed by many medical men.

Sufficient care is not always taken to see that the lymph employed is fit for use; thus it may be obtained from vesicles which have not followed a proper course of development, or in which the vaccine germ may not have sufficiently ripened for use, or from such as have become drained of true lymph, either by previous rupture or by being used for too many subjects (an ordinary well-formed vesicle will supply sufficient lymph for five cases), or the lymph may not have been properly stored in tubes or points. The lymph examiner of the Local Government Board has to reject a very large amount of the stored lymph which is sent him for this last reason alone; and if this is so with men who give special attention to vaccination, it is more than probable that the quality of the lymph stored by private medical practitioners is often very inferior.

Again, in order to gratify parents, a sufficient number of insertions are not always made. The Local Government Board recommend that insertions should be made sufficient to produce at least four separate good-sized vesicles or groups of vesicles, not less than $\frac{1}{2}$ inch from one another, the total area of which on the same day on the week following the vaccination should not be less than $\frac{1}{2}$ square inch. The statistics of the London fever hospitals of the mortality of the epidemics of 1871 and 1881 prove that this is a point of importance, the better and greater the number of the marks resulting from primary vaccination the fewer the cases; the severity of the disease varied in the same ratio.

In regard to calf-lymph, the development of the vesicles in the first child vaccinated is liable to be retarded, while that of the next few may be accelerated; it is therefore recommended that such vaccinifers be inspected on other days, besides the day week, so as to secure the best time for taking lymph.

*Erysipelas and diphtheria* have been known to be lighted up at the seat of vaccination, but those are quite accidental additions, and in no way connected with vaccination any more than with any other abrasion of the skin. Precautions should be taken that those vaccinated are not exposed to the infection of these diseases ; hence the objection to rooms used for purposes of medical relief being selected as vaccination stations. The occasional roseolous rash already noticed should not be mistaken for erysipelas.

*Irritation of the system* is set up sometimes after vaccination, and any complaints to which the child might be already constitutionally liable may put in an appearance, and will be attributed as a matter of course by the ignorant to the vaccination. Such irritation of the system may also be set up by teething, and it is better to postpone vaccination in these cases for a few months.

*Tuberculosis* may, theoretically, be conveyed by calf or human lymph, but I am not aware of any case in which it has happened.

*Syphilis* has been imparted to healthy children, but with ordinary precautions should never occur ; the cases have been very few in number. It is unfortunately true that syphilis is a very common disease, but that it is due to vaccination is not correct, and statements to the contrary are based upon ignorance. Dr. Creighton has pointed out an apparent resemblance between syphilis and vaccinia, but the same similarity exists in regard to other diseases which may be communicated by means of inoculation. We might, from our knowledge of the action of bacteria, expect even to find some secondary effects of vaccination produced, but if they do exist they are rare. Gangrenous ulceration has been noted in three cases, and was mistaken for syphilis until seen by Mr. Jonathan Hutchinson ('Archives of Surgery,' October, 1889). When the vaccinal pock leads to ulceration, etc., it is due to the entrance of one of the pus-producing germs, and is brought about by the dirty and careless habits and ignorance of the parents and guardians so-called, although some would explain that they are 'manifestations of the disease in an unmitigated form.'

Prof. Fournier has dealt with the differential diagnosis of syphilis and vaccination in a series of lectures, of which the following summary (*British Medical Journal*, November 16, 1889) may be found useful :

| *Vaccination Syphilis.* | *Hereditary Syphilis.* |
|---|---|
| 1. Begins with local affection, chancre and indolent bubo. | 1. No chancre ; begins with general phenomena. |
| 2. Has typical development in four stages, viz., incubation, chancre, secondary incubation, generalization. | 2. No typical development after vaccination. |
| 3. The general phenomena never appear earlier than the ninth or tenth week after vaccination. | 3. Is wholly independent of the vaccination as to time. |
| | 4. Is attended by syphilitic bodily habit. |
| | 5. Other manifestations of the disease. |
| | 6. History. |

| *Simple Vaccinal Ulcer.* | *Primary Chancre.* |
|---|---|
| 1. Present, if ever, twelve or fifteen days after vaccination, and after twenty days is fully developed. | 1. May appear after fifteenth day, but generally three weeks after vaccination ; at the twentieth day after inoculation it is still in its earliest development. |
| 2. All the pustules are affected as a rule. | 2. Is restricted to one or a few pustules, but only one may develop. |
| 3. Much inflammation and ulceration. | 3. Inflammation slight. |
| 4. Ulcer deeply excavated. | 4. Loss of surface, uperficial. |

| *Simple Vaccinal Ulcer.* | *Primary Chancre.* |
| --- | --- |
| 5. Much suppuration. | 5. Little discharge, crusts form. |
| 6. Irregular margin. | 6. Border not notched, slightly raised and gradually lost in floor. |
| 7. Floor of ulcer uneven and suppurating. | 7. Floor smooth. |
| 8. Inflammatory induration. | 8. 'Parchment' induration; is specific, not merely inflammatory. |
| 9. Inflamed areola, marked. | 9. Hardly any areola. |
| 10. No glandular swelling, or else inflammatory. | 10. Glandular swelling, constant and indolent. |
| 11. Complications often present, as sloughing, etc. | 11. Complications rare. |

As already mentioned, there are true vaccination eruptions which have been named roseola vaccinalis, vacc. miliaria, bullosa and hæmorrhagica ; but there may also be other eruptions complicating as those of lichen, urticaria, measles, etc. True vaccinal eruptions may be distinguished from those of secondary syphilis as follows :

| *True Vaccination Rashes.* | *Secondary Syphilitic Rashes.* |
| --- | --- |
| 1. Appear between the ninth and fifteenth day after vaccination. | 1. The earliest appearance cannot be until nine or ten weeks after vaccination. |
| 2. Absence of chancre, the evidence of inoculation. | 2. If inserted with the vaccine, the specific ulcer will be present at the site of the vaccination, and will have |
| 3. Absence of syphilitic characteristics. | 3. The true specific characteristics. |
| 4. Are attended with fever. | 4. No fever. (Fever is sometimes present, but not as a rule.) |

| *True Vaccination Rashes.* | *Secondary Syphilitic Rashes.* |
| --- | --- |
| 5. Eruptions are evanescent. | 5. Eruptions last a long time, |
| | 6. And are often accompanied by specific appearances on the mucous membranes. |

*Vaccination after exposure to small-pox.*—As the incubation stage of small-pox lasts twelve days, to successfully combat its poison, primary vaccination must be performed not later than the third day after exposure, re-vaccination not later than the fourth or fifth day.

Vaccination and re-vaccination are at present the best protection against small-pox that we have; but when the nation is farther advanced in the practice of sanitation, and will submit to stringent regulations being enforced, then we may hope to dispense with vaccination. Until that time arrives, vaccination must continue to be compulsory, and everything possible should be tried to make it safer, more protective, and less objectionable to all classes; greater care in its performance, as suggested by the Local Government Board; the postponement of the operation when thought desirable; and greater care to secure a pure supply of lymph; one objection will be removed when it will be possible to supply for each case vaccinal matter which has not passed through any animal, human or otherwise, but which has been cultivated artificially, and can be proved to be perfectly pure.

**Leprosy.**—In 1874 Hansen, of Christiania, reported the discovery of fine rod-shaped bacilli as the cause of leprosy; and they have been detected since in all parts of the world in cases of leprosy, but have not been associated with any other disease; the presence of the bacillus causes the typical development of a migratory cell into Virchow's 'lepra-cell.' Some of the bacilli are motile, others not; many possess bright spores; when they enter the body they remain quiescent for long periods probably in the lymphatic glands, but eventually the system becomes invaded by them in enormous numbers (W. R. Smith).

Soil and climate appear to have little influence upon leprosy ; it has been noted, however, that a large number of the localities specially affected are low-lying, marshy, and on the sea-coast or banks of rivers ; probably, also, the disease is more common among the ill-fed or dirty than among the well-to-do and cleanly (Bristowe). Although it thrives best in hot climates, yet, as from analogy we would expect, it is to be found also in cold countries where people huddle together in stove-warmed, badly-ventilated huts.

A disease known as granuloma or mycosis fungoides simulates leprosy very closely. It is believed to be dependent upon the action of microbes (J. J. Pringle).

**Tuberculosis.**—No doubt now exists that tuberculosis in its varied forms is a communicable disease, and due to a bacillus. A disease which even now claims an annual mortality in England and Wales of 2·89 per 1,000, equal to one-seventh of the total death-rate, deserves especial notice in order that preventive measures may be taken to remove those conditions which produce or favour its continuance.

The tubercle bacilli, as described by Koch, appear as small rods, not quite straight, but with a tendency to curve, and show slight breaks or bends ; they vary in length from half to quarter the diameter of a red blood corpuscle. The bacilli are generally found where the tubercular process is just beginning, or where it is rapidly spreading ; at later periods, when disintegration takes place in the surrounding cells, few bacilli are to be found, for they have either been destroyed or have passed on to the stage of spore-formation, when the capability of staining is lost ; their presence, however, can be shown by the infective properties possessed by the cheesy substance containing them.

The bacillus must first gain admission to the body; this it may do :

1. By inoculation through any surface abrasion.
2. Through the genito-urinary mucous membrane.
3. Through the mucous membrane of the alimentary canal by the ingestion of tubercular diseased meat and milk. This question came to the front during 1889 in Glasgow, when Sheriff Berry decided that the flesh of animals affected with tubercle was not fit for food ; this

decision has since been upheld by the superior courts. In connection with this, Professor Klein has pointed out that susceptible animals contract the disease when the tubercle bacilli, in whatever form or from whatever source, are introduced into their digestive tract: that if in an animal the lungs and thoracic lymph-glands are the only organs visibly affected, it is not to be assumed that the removal of these viscera will render the rest of the animal's body safe to be consumed as food. No part of an animal in which even a single organ is visibly affected with tubercle can be held free of the virus, for careful microscopical examination has proved that not only the lungs, diaphragm, lymph-glands, spleen and liver are affected, but that the whole vascular system of the body may contain the bacilli, which are thus conveyed to the various tissues of the body. It is not, therefore, surprising that the secretions contain the bacilli; and as tubercular deposits in the milk-glands of cows are not of rare occurrence, a large amount of milk containing the poison must be consumed; it is in children, who are the chief consumers of milk, and that generally in an uncooked condition, that we find a preponderance of cases of tubercular disease affecting the abdomen (tabes mesenterica, primary intestinal ulceration). Enormous quantities of meat from animals suffering from tuberculosis are undoubtedly consumed in this country, and apparently without danger, since the contagium is likely to be killed by the heat to which the meat is exposed during cooking, but there is always a chance that the bacilli in the inner parts of the meat may not be destroyed. According to the Mosaic Law, tuberculous meat is not eaten by Jews, and though the poorer classes of them often live in circumstances likely to predispose them to consumption, yet they suffer from it but seldom. If the experiments of Courmont detailed below are proved correct, his theory will be a strong argument against the eating of tuberculous meat, even though thoroughly cooked.

4. Through the mucous membrane of the respiratory tract and air-cells of the lungs. After childhood, by far the commonest manifestation of the disease is in pulmonary and laryngeal phthisis. Cornheim has pointed out that sputum when it becomes dry on floors, walls,

and handkerchiefs, is easily pulverized and blown about; if it contain bacilli, or rather, their spores (and it is the opinion of Koch that the bacilli are in the sputum, not in the breath) they will be set free by the drying, and be diffused throughout the air and readily inhaled into the lungs. The bacillus tuberculosis is usually endogenic, and thrives only at blood-heat, under 30° C. (86° F.). It does not grow; hence in temperate climates there is not so much chance of infection as in warmer regions; and rooms kept dirty, ill-ventilated, and over-heated, afford the bacilli opportunities which our climate usually denies them. Cases, however, have been recorded in which living bacilli were found in the bodies of phthisical patients exhumed after an interval of two or three years; either the bacilli had accommodated themselves to the temperature of the earth, or the processes of decay in the bodies had evolved heat sufficient to maintain their growth. While bacilli, we know, are killed by thorough drying, yet well-dried sputa has retained its virulence certainly for forty, probably for a hundred days; this must undoubtedly be due to spores, which can also survive prolonged immersion in water and in ice.

But, besides this real cause of the disease, there must be a soil fit for the bacillus to grow in, and without predisposing agencies this particular microbe would find it difficult to grow. It is by the removal of such agencies, together with means to prevent the entrances of the bacillus into the body, that this disease may eventually be dethroned.

*Predisposing causes.*—Heredity. It has long been recognised that the children of tubercular parents have a strong tendency to this disease, and numerous are the theories to explain what heredity is. Some condition of the tissues exists whereby they are unable to resist the attack of the bacilli, and we have been in the habit of recognising persons so affected as of a strumous disposition. M. J. Courmont has lately offered a plausible explanation why the children of a mother affected with tubercle should be susceptible to the disease. He made experiments with the soluble products manufactured by the tubercle bacilli and inoculated healthy animals with them; they did not appear to be affected, but he found afterwards, on inoculating them with bacilli, that they died in from fifteen to twenty-four hours instead of ten days. He suggests, therefore, that a tuberculous mother has these soluble products in her blood, and that they pass into the fœtal circulation, so that the child is born with tissues in a receptive state for infection. The presence of soluble products built into the child from the maternal blood might perhaps also explain the causation of congenital syphilis.

Influence of impure air, occupations, overcrowding.—The presence of tubercular diseases may be taken as a guide of the sanitary and social condition of a district. Towns with back-to-back houses, bad ventilation, and the crowding of persons within the houses furnish the greatest number of deaths from this disease. Occupations of an indoor and sedentary nature, especially if of a dusty nature, or if in such localities as described above, directly tend to produce phthisis by preventing proper use of the lungs, so that the air in parts becomes stagnant and the circulation impeded. There is also the want of exercise in the fresh air and sunlight.

Moisture of soil.—Dr. Bowditch, of Boston (U.S.A.), and Dr. Middleton, of Salisbury, were the first to point out a connection between the moistness of the sub-soil and the number of cases of pulmonary diseases with destruction of lung tissue, included under the term 'phthisis.' Dr. Buchanan, in the 'Ninth and Tenth Reports of the Medical Officer to the Privy Council,' has shown that when the soil has been dried by the introduction of sewers, the death-rate from phthisis was immediately lessened.

Age and sex do not appear to have much influence, but between the ages of twenty and thirty-five is the period of greatest mortality from pulmonary phthisis, while young children, as already noticed, supply the deaths from the abdominal type.

Previous diseases.—Many persons when in a low state of health, either from over-work, etc., or from previous illness, are liable to be affected with infectious diseases, and may be exposed to tubercular infection in meat, poultry, or milk.

*Prevention.*—In the Milroy Lectures for 1890, Dr. Arthur Ransome lays down four points which should be attended to in order to prevent tubercular infection; these are:

- Free ventilation for all indoor workers; better too much than too little.
- Out-of-door exercise for boys and girls, men and women. This implies the provision in towns of parks and recreation-grounds.
- In choosing the business or profession of those boys known to have a tendency to phthisis, let it be one where there will be little office-work, and as much out-door work as possible.
- Great care with regard to food, especially tuberculous milk.

In the treatment of cases of consumption, means should be taken to collect the sputum in suitable vessels, where it may be at once disinfected. Rooms should be well ventilated and frequently cleansed. Body and bed-clothes should be boiled or disinfected before being washed by hand. (A case is recorded of a woman who was inoculated with tubercle on the skin of the hand through washing the clothes of her phthisical husband. The production of these local tubercular nodules may lead to general tuberculosis.) After death it would be well to have the room occupied by the patient properly disinfected, as after a case of the more generally recognised infectious diseases.

**Erysipelas** is included in the list mentioned in the Infectious Diseases Notification Act, thereby recognising its contagious nature. Fehleisen's researches have definitely proved erysipelas to be due to streptococci, which are found near the sharp edge of the inflamed patch: the development of these micrococci takes place primarily in the lymphatics, both of the skin and subcutaneous cellular tissue, and it is along them that they spread; in no case of true erysipelas were the micrococci found in the blood-vessels, nor associated with suppuration. An attack of erysipelas confers a short period—several months—of immunity.

**Pyæmia, Suppuration, and Septic Diseases.**—Four forms of micrococci are recognised as being associated with septic processes. Two of these Professor Ogston of Aberdeen, describes as *staphylococci*, occurring in large groups in masses resembling a fish roe, or a bunch of grapes: microscopically, and in their effects on animals, they are alike; when cultivated, however, the *S. pyogenes aureus* produces golden yellow opaque colonies, and the other, the *S. pyogenes albus*, white opaque masses.

The third form, *Micrococcus pyogenes tenuis*, is only occasionally found.

The *Streptococcus pyogenes* microscopically resembles closely the micrococci connected with erysipelas and puerperal fever, but differs from each in the manner of growth and the effects produced in animals. These pus-producing organisms are either found alone or together; sometimes in apparently similar cases different forms may be found, the staphylococci and the last-named being the most common.

Carbuncle, whitlow, and osteo-myelitis have been determined by Garré to be due to the *Staphylococcus pyogenes aureus.*

*Pyæmia* may be divided into two groups; in one the symptoms are due to the absorption of alkaloids or other soluble products of organisms which themselves may be non-pathogenic and may not enter the body; to this the terms *Septic intoxication*, *Septic poisoning*, and *Saprœmia* have been applied.

The other group is characterized by the presence of a well-defined centre, as a suppurating knee-joint or large wound of the soft parts from which bacteria disseminate themselves throughout the system, and form local deposits (embolisms), which become separate points of infection, and from these a continuous supply of poisonous material is kept up: this is known as *Septicœmia*, or the *Micrococcus poisoning* of Ogston. It seems, however, necessary before suppuration or septic infection are set up, that there must be present some effete material, for Fränkel has often found the streptococcus pyogenes in the blood without giving rise to any symptoms.

**Puerperal fever** is a term which appears to include several different conditions. According to some, any state of pyrexia, from whatever cause occurring, in the puerperal condition is called puerperal fever; but ordinarily the use of the term is restricted to manifestations resembling those met with in pyæmia.

Professor W. R. Smith, in an inquiry into the etiology of this disease, demonstrated the presence of an organism which, in microscopical and cultural peculiarities, resembled the micrococcus of erysipelas and the streptococcus pyogenes, but which has quite a different effect upon animals.

Whether this distinction shows definitely that there is a special microbe necessary to cause this disease, or that the ordinary form of streptococcus pyogenes has become modified, it is difficult to say ; the researches, however, of Winter and Döderlein showed that the vagina and canal of the cervix uteri normally swarm with organisms pathogenic in appearance and behaviour on cultivation, but which, on inoculation, gave only negative results ; but when the lochia was present in the vagina, organisms were found which produced abscesses in animals. This tends to show that, according to circumstances, they may be in an attenuated or in a virulent condition.

Normally organisms do not exist above the internal os either in the cavity of the uterus, or in the Fallopian tubes, whether the female be puerperal or non-puerperal. When they do enter these parts, as by the hands or instruments of attendants, pyrexia is produced and the organisms thereby destroyed. The pyrexia results from the absorption of the toxic products, but true pyæmia may be set up by the entrance of septic matter into open blood-vessels. Dr. Braxton Hicks has pointed out that this might be produced by sudden movements or by sudden inspiratory efforts, as laughing.

*Scarlet fever and the puerperium.*—Some hold that scarlatina may produce a disease resembling septicæmia, but most are agreed that scarlatina always 'breeds true.' In puerperal cases the scarlet fever poison might enter either by the usual channels or by the genital organs ; in the former case the disease would run its ordinary course, but in the latter the incubation stage is shortened (three to five days), the rash appears promptly, and the throat may not, or only slightly, be affected (Meyer, Boxall, etc.). Experience shows that puerperal women are not so liable to contract scarlatina as has hitherto been supposed, but when they do suffer from it the results are more likely to be serious. In the early stages of the disease pelvic inflammation and septicæmia may be merely coincidences with the scarlet fever, but in the later stages, especially when the poison has entered by the genital organs, it would be due to secondary septic processes, similar to those that occur in the throat (secondary) in non-puerperal cases.

**Anthrax.**—This disease is one affecting horses, cattle, sheep, and goats, to a considerable extent in some countries, and depends upon a large bacillus, of which mention has already been made. It is transmitted to men engaged in slaughtering the diseased animals, or in working with their hides and fleeces, hence the name *Woolsorter's disease* sometimes applied to it. There are two principal varieties of the disease, dependent upon the manner in which the microbe finds entrance to the system ; in one there is a characteristic *malignant pustule* present, in the other there is no external lesion, as the spores are taken into the respiratory (Greenfield) or alimentary (Koch) tracts.

To prevent the spread of anthrax, the isolation and slaughtering of infected animals is necessary, and the bodies should, when possible, be burned ; otherwise they should be buried without being opened, as spore formation does not take place in the absence of oxygen. The discharges of infected animals should, when possible, be collected, disinfected, and burnt.

Inoculation with attenuated virus has been tried successfully by Pasteur as a prophylactic.

**Rabies.**—Rabies is another of those diseases which may be transmitted from the lower animals to man, and of which mention has been made in an earlier part of this chapter in reference to Pasteur's treatment by protective inoculations. The disease usually develops within four months, but the incubation stage may extend to two years. On the Continent it has been stated that four-fifths of the persons who are returned in official lists as having died from hydrophobia, have really succumbed to a dread of the disease, or 'hyssophobia.' Rabies may be spread by wolves and cats as well as by dogs, but as it is chiefly from dogs that it is communicated in this country, Dr. George Fleming, C.B., has suggested the following precautions to be taken with a view to its total suppression :

1. All dogs to be muzzled for a period covering the extreme limit of the latent stage—say one year.

The presence of a muzzle prevents biting, and is evidence that the dog is cared for ; when rabies is suppressed the muzzle can be abolished.

It may be noted here that the not very vigorously-enforced muzzling order of the end of 1885 reduced the mortality in London alone from twenty-seven to nine in the year 1886.

2. All dogs over three months to be registered and licensed ; to wear a collar with owner's name and address, and a special number or mark affixed thereto.
3. All unlicensed and vagrant dogs to be destroyed.
4. Suspected animals bitten by rabid dogs to be destroyed.
5. Owners of dogs to be compelled to make declaration of the existence of the disease.
6. Owners to be responsible for damage inflicted by their dogs.
7. A period of quarantine to be enforced on all imported dogs.

There are also a series of complaints depending upon higher members of the vegetable kingdom than bacteria ; foremost among these may be mentioned *Madura-foot*, due to a small truffle-like fungus, known as Chioniphe Carteri ; *Actinomycosis*, caused by the ray-fungus or actinomyces. Under the microscope the little yellow grains are seen to consist of a number of radiating threads with swollen club-shaped ends forming a sort of rosette. In cattle it affects the jaws by the formation of hard nodular tumours, and by the enlargement and induration of the tongue ('wooden tongue'). Occasionally the skin and lungs are similarly affected. A few cases have been recorded in which this disease has appeared in man, and, as first pointed out by Dr. Israel, is characterized by the presence of metastatic abscesses in the lungs and elsewhere containing this fungus.

*Thrush* is due to the oidium albicans, supposed to be identical with the oidium lactis ; it is usually strictly confined to mucous surfaces, but cases are on record showing that it occasionally enters the circulation, and may give rise to serious visceral lesions, and even to multiple cerebral abscess.

Low forms of fever, with sore-throat, sickness and diarrhœa, have occurred from the presence of moulds and fungi growing in damp houses.

The occasional presence of *sarcinæ* and the *yeast* plant in the stomach may also be mentioned; the former is sometimes found in urine.

Various skin-diseases are attributed to the presence of vegetable parasites, as

Molluscum contagiosum.
Tinea tonsurans, from the trycophyton tonsurans.
Tinea favosa „ achorion Schönleinii.
Tinea versicolor „ microsporon furfur.
Erythrasma „ trycophyton minutissimum.
Alopecia areata; some cases may be due to microsporon Audonii.

### Animal Parasitic Affections.

| *Cestoda, or Tænida—* | *Larval form.* | *Host.* |
|---|---|---|
| Tænia solium | Cysticercus cellulosæ | Pig. |
| „ mediocanellata | „ | Ox. |
| „ echinococcus (dog and wolf) | Hydatid | Man. |
| „ marginata (dog) | Cysticercus tenuicollis | Man. |
| Bothriocephalus latus | Cysticercus | Pike and eels. |

| *Hæmatoda, or round worms—* | | *Habitat.* |
|---|---|---|
| Ascaris lumbricoides | | Small intestine. |
| Oxyuris vermicularis—threadworm | | Colon. |
| Trichocephalus dispar | | Cæcum. |
| Dochimus duodenale | | Duodenum |
| Trichina spiralis | requires two hosts { Pig, Man } | Muscles. |
| Filaria sanguinis hominis | „ { Mosquito, Man, etc. } | Lymphatics and blood, etc. |
| Filaria medinensis „ dracunculus—Guinea worm | | Cellular tissue. |

Strongylus gigas and pentastoma denticulatum are rare.

| *Trematoda—* | *Habitat.* |
|---|---|
| Bilharzia hæmatobia | Abdominal veins. |
| *Distoma hepaticum, or fluke*—eggs developed in water. | Liver. |

## CHAPTER IX.

### THE PREVENTION OF INFECTIOUS DISEASES.

This subject naturally divides itself into two heads: measures which are general and special.

The general implies that permanent provision for securing the public health, which is, or ought to be, the aim of every sanitary authority; and in the words of Dr. Buchanan, it is to be remembered that in proportion as a district is habitually well cared for, the more formidable emergencies of epidemic disease are not likely to arise in it.

A reference to statistics will show that while much has been done in this respect, there is much still to be done even in this country. At the commencement of the present reign the death-rate of London was 24 per 1,000; it is now 19 per 1,000; while in prisons where sanitary works have been completed, Sir Edwin Chadwick states that epidemic visitations have been banished, and the death-rates of those who enter without developed disease upon them, have been reduced to one-third of the general death-rates. In the army the same improvement can be shown, with great saving to the country both in men and money. In Glasgow Dr. Russell, the Medical Officer of Health, reports that during the last decade there has been a saving of not fewer than 10,000 lives, which he ascribes to reductions of overcrowding, by the demolition of houses on insanitary areas and the erection of model dwellings in their stead; by more efficient scavenging and other sanitary work; so that out of every 10,000 of the population there have died of fevers only seven in place of twenty. And in many other places the death-rates have been diminished by a third and even a half.

As regards *malarious* diseases, observations in Algeria, Italy, and elsewhere, have shown that the planting of gum-trees, especially the eucalyptus globulus, has had wonderful effect in rendering healthy districts previously uninhabitable. This beneficial action is due in part to the essential oil which is given off from the trees, and to the products of its atmospheric oxidation ; and in part to the great absorption of water from the soil, some of which is utilized in the rapid growth of the tree, and the rest is evaporated with the essential oil from the leaves. It has been noted in Algeria that this evaporation was eleven times the rainfall. The good effects produced in chest-diseases by residence among pine-woods is no doubt, in great part, also due to the evaporation and oxidation of the essential oil.

The *special* measures for the prevention of infectious disease include early notification (this is now provided for by law as regards small-pox, cholera, diphtheria, erysipelas, scarlet, typhus, enteric, relapsing, continued, and puerperal fevers), increased vigilance in the abatement of nuisances, in attention to the water supply, in the prevention of overcrowding, the enforcing of greater cleanliness in houses and in public thoroughfares, house-to-house visitation, and the distribution among the people, by handbills and otherwise, of information as to what real precautions they can take, and what they should do on the appearance of symptoms. Sometimes it is necessary to close schools and other establishments wherein members of many different households are accustomed to meet.

Abroad, other nations resort to a system of *quarantine*, to prevent cholera and other infectious diseases obtaining a footing in their country. Suppose a ship arrives at a foreign port having a case of cholera on board, they require the whole of the passengers and crew, healthy as well as sick, to be kept together until such time as they can be declared free of disease. If cholera has already obtained a footing in a country, they endeavour to prevent people leaving the infected district by the establishment of *cordons sanitaires ;* but these measures have always been found futile to prevent the spread of disease, and the example of this country is now being followed elsewhere. The practice here is, as far as possible, by improved water-supply, drainage, and cleanliness, to offer to cholera, should it be imported, no nidus or pabulum for its development. Should cholera arrive at any port in the United Kingdom, dependence is placed upon medical inspection, isolation of the sick, and disinfection.

The instructions laid down by the Conference of Rome in 1885 are that in British ports, etc., the cholera sick are to be isolated in hospitals already prepared, and those suspected to be detained forty-eight hours; all healthy persons to be allowed to land, subject to notification of destination by the port sanitary authority to medical officer of health of proposed destination.

If cholera breaks out during a voyage, the room in which the case occurs must not be used until thoroughly disinfected.

In the case of infected ships at foreign ports, there must be—

1. Medical inspection.
2. Free pratique to the healthy; but if the voyage is under ten days, detain for twenty-four hours; but if a case of cholera be on board, all passengers must be landed and detained for five days, the sick being isolated.

Special rules apply to the Mediterranean. All on suspected vessels must be landed and isolated in properly constructed places for from three to six days, according to whether the ship carried a medical officer.

If the ship be infected, there must be five days' detention. All on board ships connected with the Mecca Pilgrimages must be detained five days if there is any suspicion of cholera.

*Medical relief.*—In this country cholera often begins in a comparatively tractable form of what is called 'premonitory diarrhœa.' It is deemed essential by Dr. Buchanan that where cholera has appeared, arrangements should be made for affording medical relief without delay to persons attacked, even slightly with looseness of bowels.

*Isolation.*—It is absolutely necessary in diseases like cholera, typhus-fever, and small-pox, that the patients should be immediately isolated in proper hospitals if they are at all fit to be moved. For other infectious diseases, isolation at home may suffice, but unless it is complete (and this it very often is not) it is much better that the patients be removed to a hospital, the use of which by all classes of the community should be encouraged, and with this view it is better that this provision be not made by the poor law authorities.

The Local Government Board have issued a memorandum on the subject of isolation or infectious diseases hospitals, with some model diagrams, and in the supplement to the Tenth Annual Report, there is a long report on the hospitals and disinfecting stations then existing.

It is recommended that villages should combine to provide a hospital, or else each provide a four or six-roomed cottage, or arrange with cottage-holders not having children, that they should receive and nurse, on occasion, patients requiring such accommodation. In towns or large districts permanent and special buildings are requisite, and ought to be in readiness *before* infectious diseases threaten; if the Infectious Diseases (Notification) Act, 1889, is to be of use, the provision of hospitals is imperative. It is important also to provide a house for healthy members of a family when the patient cannot be moved, or while their own rooms are being disinfected.

In urban districts the hospital must not be more than two miles away (small-pox hospitals may be further if easily accessible), and should be placed outside towns.

In rural districts the hospital should not be more than four or five miles from the most populous place, *e.g.*, a market town.

*The site.*—A gentle slope is best, with dry soil, free circulation of air, abundant and wholesome water-supply, and facilities for drainage.

*Acreage.*—Twenty patients are allowed to each acre; an interval, 40 feet clear space, must everywhere be interposed between the boundary of the hospital site and every building (permanent and temporary) used for the reception of infected persons or things; the site must have an enclosing wall 6 feet 6 inches high, and should be provided with one or more gateways, with porters' lodges, where goods may be left and enquiries made.

*Number of beds.*—There is always probability that room will be wanted at the same time for two or more infectious diseases which have to be treated separately. The permanent provision to be made in a town should consist of not less than four rooms in two separate pairs, each pair to receive the sufferers from one infectious disease, men and women of course separately. The number of cases for which permanent provision should be made must depend upon various considerations, among which are the size and the growth of the town, the lodgment and habits of its population, and the traffic of the town with other places ; for scarlet-fever one bed per 1,000 of population is allowed, but this would not be sufficient in a town where a large number of children are congregated in schools.

Since improperly diagnosed cases may be sent into hospital, it is desirable to have a room or rooms where such cases may be isolated for a time.

An administrative block, with rooms for the staff ; an isolation ward ; laundry, mortuary, disinfecting room, and an ambulance must be provided.

For small-pox there must be a separate block with its own kitchen and nurses' rooms, a laundry and ambulance, and, if possible, a separate entrance from the rear of the grounds.

*Minimum distance between blocks.*—If, of two buildings, one is higher than the other, the distance between the two must be equal to the height of the higher ; if two buildings are the same height, then the distance must be one and a half times the height.

Below the *floors* concrete or asphalt must be laid down ; the space well ventilated ; the boards of the floor should fit into one another so as to leave no crevices, and should be polished.

The junction of the floor and walls should be round, and tops of doors should be cut slant so that dust can be easily seen and removed.

*Windows* should be placed opposite one another, facing south of east and north of west ; by this means both sides are brought under the influence of the sun's rays, and direct exposure to the east wind is prevented. They should extend from 3 feet above the floor to within 6 inches from top of walls. One window should be between two beds and one at end of room ; it should be an ordinary sash window with an upper flap. One square foot of window is to be provided for every 60 or 80 cubic feet of air in the ward.

*Floor space per bed* = 144 square feet.

*Cubic space per bed* = 2,000 cubic feet.

*Height of wards* = 14 feet ; all above that is not to be taken into account in calculating cubic space. Longitudinal wall space per bed = 8 feet.

*Warming.*—There should be one fireplace for every 25 or 30 feet of ward ; if only one is required it should be in the centre of a side wall ; if two, then one at each end.

The temperature of the wards is to be 60° F.

Hospitals are often also provided with ventilators below the heads of the beds, and the air is made to pass over hot-water pipes in winter.

*Children* are to have not more than a quarter less space than adults, but the full amount when possible.

Hospitals are now built on the pavilion or block plan, or in circular form. A *pavilion* consists of one, two, or three floors, each containing an oblong ward, rooms for convalescents, for nurses, etc. At the corners of the wards turrets are built to contain w.c., bathing, and lavatory accommodation ; these are separated from the ward by short ventilated lobbies. The various pavilions are joined by means of terraces and corridors. In all hospitals the administrative department should occupy a separate block, in which also should be the rooms of the various officials, the kitchen, and dispensary.

*Circular ward* hospitals, as suggested by Mr. John Marshall, exist at Antwerp, Greenwich, and elsewhere. The diameter of a ward varies from 20 to 60 feet ; on the roof a day or sun-room is sometimes constructed. The advantages claimed for this form are that

Supervision is better.
Warming is more easily and more equably carried out ; the maximum of sunlight is obtained.
Ventilation is better.
Cleanliness is more easily secured.
The management is more economically conducted.

There is, however, a great waste of space in the centre of the ward. For infectious disease hospitals the pavilion form is the more suitable.

*Small-pox hospitals.*—It has been suggested that in infectious disease hospitals, but especially with small-pox ones, that the air should be extracted from the wards by a flue, so that the poison may be drawn through a furnace and thereby destroyed.

**Disinfection.**—The object of disinfection is to destroy the infective matter which, when received into the body of an apparently healthy person, has the power of producing disease. There is little doubt that this infective matter is a living organism or a product of a living organism. Disinfection then, in one form or another, should be able to destroy both organism and product.

Until the researches of Koch, Klein, H. F. Parsons, and others, no precise knowledge existed of the relative values of the various chemical agents used as disinfectants. It was found that it was not an easy matter to kill some organisms, especially those producing spores, as the spores, as already mentioned, are much more tenacious of life than the fully-developed organism; any means which can overcome the spores of the bacillus anthracis will be able, it is assumed, to destroy any other microbe. Threads, steeped in cultures of both spore-bearing and non-spore-bearing organisms were exposed to the action of certain chemicals, and afterwards tested by cultivation or by inoculation.

*Sulphurous acid gas*, 1 part in 100 of air, killed non-spore-bearing organisms, if dry in twenty minutes; if moist, in one minute.

Chloride of zinc (5 per cent.), absolute alcohol, glycerine, chloroform, sulphates of copper, zinc, alumina, and iron (5 per cent. watery solutions), boracic acid (5 per cent.), had no destructive effect on anthrax spores. They were destroyed by exposure for one day to the action in watery solution of either of the following substances, viz.:

Chlorine.
Bromine (2 per cent.).
Iodine.
Creolin (6 per cent.).
Corrosive sublimate (1 per cent.).
Permanganate of potash (5 per cent.).
Osmic acid (1 per cent.).

And after longer periods of exposure by

Ether.
Oil of turpentine.
Hydrochloric acid.
Quinine (1 per cent.).
Chloride of iron (5 per cent.).
Arsenious acid (1 per cent.).
Chloride of lime (5 per cent.).
Carbolic acid (5 per cent.).

Although many of these agents had little or no effect upon the anthrax spores, yet the strength used (or even more dilute solutions of some of the agents) would be sufficient to destroy micrococci and other non-spore-bearing microbes, as in the experiment with sulphurous acid gas. Moreover, it is evident that free exposure to air, or to oxidizing agents, as permanganate of potash, peroxide of hydrogen, ozone, etc., must be fatal to anærobic organisms.

If a patient suffering from an infectious disease has to be treated at home, the following rules (based on those recommended by the Society of Medical Officers of Health) should be observed:

(1) The patient shall be at once separated from the other inmates of the house, and, if possible, placed in a top room, and have that floor devoted to him and his attendant.

(2) All bed curtains and other hangings, carpets, and all articles of dress and the like in wardrobes and cupboards, and all unnecessary articles of furniture should be removed.

(3) The room should be well ventilated, windows should be kept partly open (the patient being protected from draughts or chance of a chill by a screen when necessary), communication with the chimney free, and if the weather or size of the room permit, the fire burning. The floor should be sprinkled with disinfectant fluid and cleansed daily.

(4) The door should be kept closed, and a sheet, kept wet with sanitas or with solution of carbolic acid, hung outside it so as to cover every crevice.

(5) Everything that passes from the patient (sputum, vomit, urine, fæces) should be received in vessels containing a disinfectant; and an additional quantity of the disinfectant should be added to the vessel *before* removing it from the room and emptying it into the closet. All super-abundant food or drink, and all scraps and refuse, should be mixed with disinfectant, and under no circumstances partaken of by other persons; it is best to burn as much as possible.

(6) Pieces of rag used for wiping discharges from the nose or mouth should be burnt immediately after use.

(7) All cups, glasses, spoons, or such like articles used in the sick room, should be placed in some disinfectant solution before leaving it, and subsequently washed in hot water.

(8) All bed and body linen after use should at once, and before leaving the room, be put into a disinfectant solution (as corrosive sublimate with sanitas), and after remaining in this at least an hour, may be washed. When the grosser dirt has been removed by rinsing in water, the articles may be boiled—if this were done first the albumen would be coagulated and the clothes stained.

(9) The patient's person and bed should be kept scrupulously clean, and when, during the progress of the disease, scales or crusts form upon the skin, their diffusion should be prevented by smearing the surface of the body from head to foot daily with oil (eucalyptus or sanitas oil). Sanitas may be added to the water used for washing.

(10) Nurses in attendance should, if possible, be such as have already had their patient's disease; their dresses should be of washable material; they should keep their hands clean, adding sanitas or Condy's fluid to the water in which they wash, and should as far as possible avoid inhaling the patient's breath, or other emanations from his person or discharges. They should remain with the patient, or if compelled to leave the room—leave it under proper precautions, and under no circumstances mix with other members of the household.

(11) Visitors should not be allowed, or, if allowed, should conform to the conditions required of the ordinary attendant.

(12) In cases of small-pox members of the household should be re-vaccinated.

(13) The patient must not be allowed to mix with his family until all peeling of the skin has ceased, or until all specific phenomena of disease have disappeared, and until he has been well purified by the use of warm baths containing a disinfectant. Clothes used during the time of illness, or in any way exposed to infection, must not be worn again, or put away in drawers or wardrobes until they have been properly disinfected.

(14) When the sickness has terminated, the sick room and its contents should be disinfected and cleansed.

(15) The house in which the patient suffering from infectious disease resides should, during his illness, be well ventilated and kept very clean, all sinks, water-closets, traps, and gullies, should be in good order, and have solutions of ferrous sulphate—green copperas—(1 lb. to a gallon of water), or carbolic acid (No. 4, a $\frac{1}{4}$ pint to the gallon), or Condy's fluid (the red with 50, the green with 30, times its bulk of water) poured into them daily; dust-bins should be regularly emptied, all offensive accumulations removed or disinfected by the free use of chloride of lime, or sanitas powder. All water butts and cisterns should be kept clean and well covered. The greatest possible care should be taken to prevent contamination of the drinking water.

(16) Should death occur, the body should as soon as possible be placed in a coffin, which should be filled up with chloride of lime, charcoal, or sanitas saw-dust, and the lid at once screwed down; the funeral should take place at an early date. Mourners should not meet in the room in which the death took place. If the body is a danger to health it may be removed to a mortuary. (See also Infectious Diseases Prevention Act, 1890.)

All the mercuric salts which can be kept stable and in solution have powerful germicidal properties; of these

*Corrosive sublimate* is the most trustworthy disinfectant to use, but it is poisonous, it corrodes iron and other metals, and is decomposed by contact with them; it unites with albumen to form an inert compound unless combined with an acid. For disinfecting excreta, clothing, floors, etc., the following solution is recommended by the Local Government Board: it is made with half an ounce of corrosive sublimate, one fluid ounce of hydrochloric acid to 3 gallons (a bucketful) of common water. It should be coloured with 5 grains of commercial aniline blue, with sulphate of copper or permanganate of potash to prevent accidents; it should be used without further dilution, in wooden or earthenware house-tubs or buckets.

The solution of corrosive sublimate in sanitas (known as Mercuric Bactericide) is also a good form in which to use it.

*Sanitas fluid* is an aqueous solution of peroxide of hydrogen with soluble camphor ($C_{10}H_{18}O_3$) and thymol, and is produced by the oxidation of turpentine in the presence of air and water. Sanitas oil remains when the fluid is removed, and contains various oxidized bodies and an organic (probably camphoric) peroxide, which gives off peroxide of hydrogen and camphoric acid to the air. Sanitas acts both as a disinfectant and an oxidant, and being non-poisonous by itself, it is the safest for general use. By its power of rapid oxidation it stops putrefactive decomposition (Kingzett).

*Chloride of lime* is useful for excreta ; if used for clothing 2 ounces to a gallon is strong enough, stronger will destroy the materials.

*Ferrous sulphate* is a cheap deodorant, but, according to Koch, is not a disinfectant proper.

*Carbolic acid* has a powerful restraining effect upon the growth of bacteria, but as a disinfectant is very feeble even in vapour. Its compounds and solutions of it in alcohol or oil are less powerful than carbolic acid itself. Koch prefers it (5 per cent. solution) for disinfecting the excreta and soiled linen of cholera patients.

*Permanganate of potash* is a good deodorant and a true disinfectant to some extent, but its action is much weakened if the infective matter is mixed with a quantity of other organic matter. It is non-poisonous, but stains clothing, etc.

Bedding, blankets, carpets and such like, which cannot well be disinfected at home, must be disinfected by *steam* at low pressure, as recommended by Dr. Meyer. Where articles have been soiled with albuminous matter, the heat will cause coagulation and a permanent stain, unless the soiled parts have been previously washed in cold water.

If the bedding or other articles are very filthy or dilapidated they should be destroyed by fire, and compensation given for them (Section 121, Public Health Act). Leather and letters should be exposed to dry heat only.

After the room has been prepared by the removal of persons, and of such articles as are best disinfected by heat, and by the closure of windows, chimney outlet and all crevices, it may be purified by the aid of sulphurous acid gas, or chlorine.

*Sulphurous acid* is produced by burning roll-sulphur (with a little spirit) in a pipkin over a small fire in the centre of the room, the floor being protected by an old tray; 1 lb. of sulphur to each 1,000 cubic feet of the room is the quantity usually employed. This only gives a strength of about 1 per cent., which Dr. Alfred Carpenter long ago pointed out as being quite inadequate, especially after small-pox. Letheby recommended $\frac{1}{2}$ oz. for 10 cubic feet. Koch's experiments show that the addition of moisture would increase the effect.

*Chlorine* also requires the presence of moisture, which may be obtained by well steaming the room. The gas may be evolved by gently heating a mixture of four parts common salt, and one part of manganese dioxide with two parts by weight of sulphuric acid, and two of water; or of four parts by weight of strong hydrochloric acid, with one part of manganese dioxide.

*Nitrous acid* can be evolved from copper filings by the action of dilute nitric acid. It oxidizes organic matter, and has been recommended for dead-houses. Iodine, bromine, euchlorine, etc., have been suggested, but they are too expensive for general use.

After the room has been closed for twelve hours, it should be thrown open to the light and air and thoroughly ventilated; all wall-paper should be stripped from the walls and burnt; all wood-work and furniture should be washed over with a mixture of sanitas and water; after this, if the case has been one of small-pox, or other virulent disease, it will be well to apply a solution of corrosive sublimate (1 in 5,000), taking special care with crevices and cracks in the floor. The ceilings and walls must be thoroughly washed, and lime-whited, or re-papered.

*Anti-septics.*—In the foregoing part of this chapter we have dealt with the destruction of microbes themselves by germicides, but there is still the class of disease in which the symptoms are caused not by the entry of the germ, but of its products. Here it is not always necessary that the microbe be killed, it is sufficient if its action can be checked until all means of entry of its product into the system are closed as by the healing of wounds. For this purpose the chemical agent need not be so powerful as when germicidal action is required: thus corrosive sublimate of the strength of one part in 100,000 of water will prevent the development of organisms (if no albumen be present). Some agents have strong antiseptic powers, but low germicidal ones, as in the case of carbolic acid; but the number of substances used as antiseptics is too great to admit of detailed description here. As regards those poisonous ferments produced by various organisms, chemical research into their nature has not as yet given us means of destruction, but from the experiments of Kingzett it is possible their poisonous properties may be removed by further processes of oxidation, thus tyrotoxine, which is believed to be identical with diazobenzol (V. C. Vaughan), is decomposed upon exposure to the air.

## CHAPTER X.

### DISPOSAL OF THE DEAD.

*Mortuaries.*—'When the body of a person who has died from any infectious disease is kept in an apartment wherein persons reside or sleep, or when any corpse in such a condition as to endanger the health of the inmates in the same house or room is retained therein, a magistrate is empowered, on a certificate signed by a medical man, to order the removal of the body, at the cost of the local authority, to any mortuary provided by it.' It is, therefore, desirable that all local authorities should avail themselves of the power given them in the Public Health Act, 1875, to erect mortuaries in their districts (see Model By-laws).

If a dead body be exposed to a temperature of 60° F., in three days it will begin to putrefy and give off offensive gases. If a body must be kept longer than that time it should be in a well-ventilated room, and should be approached as little as possible. The presence of aërial disinfectants is desirable. As a result of inhaling the effluvia from dead bodies the writer has known several cases of severe illness, as pulmonary abscess, etc.

A post-mortem room is often included within a mortuary; but although this would appear to be an appropriate situation for it, the legislature has enacted that a post-mortem room may be provided, but not at a mortuary or workhouse. The reason for this prohibition is evidently to remove any suspicion that the fact of taking a body to a mortuary necessitated dissection.

Mortuaries are provided in connection with hospitals and cemeteries, while others should be provided in central positions in districts for the reception of bodies to await identification and the coroner's inquest. It has been computed that for every 50,000 of the population of any town a mortuary should be provided (Boulnois).

As to the ultimate disposal of dead bodies, two methods are at present in use, viz., burial and cremation.

*Burial.*—When burial is performed in a perishable coffin (the 'earth to earth' system advocated by Mr. Seymour Haden) in a suitable soil, the body is reduced to an elemental condition in from three to six years ; but it is not often that suitable ground can be acquired, and it is more than doubtful that the earth would be able to exercise an absorbent action on the gases evolved if the interments were frequent and numerous : they would then vitiate the atmosphere. Dr. Parsons, in a Local Government Board memorandum, has embodied what he considers the sanitary requirements of cemeteries : The soil should be of an open, porous nature, with numerous close interstices, through which air and moisture may pass, in a finely divided state, freely in every direction. It should be free from water or hard rock to a depth of at least 8 feet. If it has to be drained, it must be raised above the drainage level of the locality. Loam and sand with vegetable make the best soil ; clay and loose stones the worst. The site to be chosen for a cemetery should be in a neighbourhood in which building is not likely to take place, as the erection of houses interferes with the free play of air around and over it ; a cemetery must not be constructed within 200 yards of any dwelling-house without consent of the owner or occupier. It should stand exposed to north or north-east winds. Ground air and ground water are both liable to be contaminated ; care must, therefore, be taken to prevent wells and streams and foundations and cellars of houses being polluted. It would be well if a cemetery could be placed at a lower level than the town, so that the water which drains from it may not flow under the town. Even when bodies are placed in vaults and in lead and wooden coffins decay is merely postponed, and, sooner or later, the offensive products must find means of escape ; hence the objection to intra-mural interments. A strip of ground 15 to 30 feet wide all round must be kept free from interments on the interior of the boundary fence. This strip would afford room for a gravel or asphalte walk, and next the fence should be planted rapidly-growing shrubs and plants, so that decomposing matters percolating to the exterior of the cemetery may be arrested and assimilated by them.

*Space.*—With regard to the amount of land necessary, the usually estimated minimum is a quarter of an acre of land for every 1,000 of the population of the community.

The regulations issued from the Home Office in 1863 for grounds under the Burial Acts require that

> The grave spaces for persons above twelve years of age shall be at least 9 feet by 4 feet (4 square yards); under twelve years of age 6 feet by 3 feet, or $4\frac{1}{2}$ feet by 4 feet (2 square yards). There must be at least a foot between each grave.
>
> No unwalled grave shall be reopened within fourteen years after the burial of a person above twelve years of age, or within eight years under twelve, unless to bury another member of the same family, in which case a layer of earth not less than 1 foot thick shall be left undisturbed above the previously buried coffin.
>
> No coffin shall be buried in any unwalled grave within 4 feet of the surface of the ground, unless it contains the body of a child under 12 years of age, when it shall not be less than 3 feet below the level.

To the many objections to burial must be added the danger that accrues from the bodies of persons who have died of an infectious disease. It is possible that pathogenic microbes are destroyed by germs of putrefaction, but this destruction is not complete, for Pasteur has shown that spores may resist putrefactive action for years ; and, as the home of many pathogenic microbes is the soil, no better arrangement could be desired for their propagation. As pointed out by Darwin, earth-worms play an important part in propagating disease by bringing up to the surface of the ground specific germs which have been buried as deep as 7 feet. The above considerations, coupled with the fact that land used for a cemetery is a dead loss to the country, are producing a feeling that *cremation* is the safest and best way to dispose of the dead. The chief objection to cremation is that crime might be hidden, as poisons would be dispelled by the heat.

Disused burial-grounds may be laid out as recreation grounds by local authorities, under the Open Spaces Acts, 1881 and 1887.

## CHAPTER XI.

### DUTIES OF THE MEDICAL OFFICER OF HEALTH.

THE duties of the medical officer of health can be learned only by practical experience ; but, for his guidance, the Local Government Board has issued an order (March 28, 1889) defining what they are. The following embodies the principal clauses :

1. He shall inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously the public health within the district.

2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

3. He shall by inspection of the district, both systematically and at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

4. He shall be prepared to advise the local authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the local authority ; and in cases requiring it, he shall certify, for the guidance of the local authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, *he shall visit the spot without delay and inquire into* the causes and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorized, assist in the execution of the same.

7. Subject to the instructions of the local authority, he shall direct or superintend the work of the inspectors of nuisances in the way and to the extent that the local authority shall approve, and on receiving information from any inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps authorized by the statutes in that behalf as the circumstances of the case may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the local authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, exposed for sale, or deposited for the purpose of sale or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken, and carried away, in order to be dealt with by a justice according to the provisions of the statutes applicable to the case.

10. He shall inquire into any offensive process of trade carried on within the district and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

13. He shall report in writing to the authority from time to time (weekly, fortnightly, or as directed) on all deaths (classified according to age, cause, and locality), and, so far as practicable, on all important sickness in the

district ; on such newly-observed unwholesome conditions as the authority can abate, and on the completion, progress, or neglect of improvement in matters previously reported on.

15. He shall also prepare an annual report, to be made to the end of December in each year, comprising a summary of the action taken during the year for preventing the spread of disease, and an account of the sanitary state of his district generally at the end of the year. The report shall also contain an account of the inquiries which he has made as to conditions injurious to health existing in his district, and of the proceedings in which he has taken part or advised under any statute, so far as such proceedings relate to those conditions ; and also an account of the supervision exercised by him, or on his advice, for sanitary purposes over places and houses that the local authority have power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, and to factories and workshops. The report shall also contain tabular statements (on forms to be supplied), of the sickness and mortality within the district, classified according to diseases, ages, and localities.

16. He shall give immediate information to the Local Government Board and to the County Council of any outbreak of dangerous epidemic disease within the district. He shall also transmit to them a copy of each annual and of any special report, and any report made by him under the Artizans Dwellings Acts, 1868 to 1885, shall be deemed a special report.

In drawing up the annual report, it is necessary that the population of the district should be ascertained as correctly as possible. As the census is taken only once in ten years, the population for any time during the decade must be estimated. The Registrar-General assumes that the *rate of increase*, or of decrease, which prevailed between the last two enumerations will continue during the next ten years. For small places it may be sufficient to add for each year one-tenth of the *actual increase* shown at the last census ; but in large towns this would lead to a considerable amount of error ; the annual increase may be due to immigrations, as well as to the excess of births over deaths, and by the former method no notice would be paid to the increase of population which would ensue from the annual increment. The following example, taken from the Sanitary Record Diary, will illustrate this: The enumerated population of the borough of Sheffield was 239,946 in 1871, and was 284,508 in 1881, giving an average annual increase of 4,456·2; five and a quarter years after the last census, the population as estimated by the first method would be 307,903, and by the second method 310,957. The necessary calculations can be made most conveniently by the use of logarithms.

Populations are estimated to the middle of the year, thus an additional quarter has always to be taken into account. Thus, to estimate the population of a place for any given year in the present decade, the logarithms of the two last census returns are to be found, and the lesser subtracted from the greater: this will give the logarithm of the rate of increase for the last decade; a tenth of this will be the logarithm of the annual rate of increase, which, multiplied by the number of years since the last census, plus a quarter, and added to the last *enumerated* population, gives the *estimated* population for the year in question; or, to put it as a formula:

Let $a$ be the population in 1871,
" $b$ " " " 1881,
" D be the difference between $a$ and $b$,
and " $\frac{D}{10}$ = the annual rate of increase.

Then, assuming that the population is increasing or decreasing in the same ratio in this decade as in the last, the logarithm of the population in the middle of 1890

$$= \log. b + 9\tfrac{1}{4}\left(\frac{\log. D}{10}\right).$$

Or, the annual rate of increase having been found by logarithms, and the estimated population for the year immediately preceding being known, the population for the current year may be obtained by multiplying those two factors together.

It must be kept in mind that there are often in operation causes known to the local medical officer which would render calculations, such as the above, incomplete and fallacious. Such causes as : demolition of property, opening of common lodging-houses, lying-in and other hospitals, workhouses, immigration, emigration, etc., should be recognised by the medical officer of health, and the necessary corrections made, else the death and other rates will appear higher or lower than actually is the case.

The late Professor Parkes states that the most important statistical inquiries applied to health relate to :

1. *The proportion of births to population.*

2. *The relative number of live and still-born*, of *premature* and *full-grown children.*

3. *The number of children dying in the first year*, with sub-groups of sex and months—two great periods of mortality in the first year of life occur, one in the first week, the other about the time of weaning.

4. *The amount of sickness to population.*

5. *The amount of yearly mortality in a population*, or deaths to population, grouped according to age, sex, disease, etc. Both the birth-rate and death-rate are calculated per 1,000 persons living, and may be compiled from the weekly, monthly, quarterly, or other returns, by a proportion sum :

Estimated population : 1000 : : total births for year : $x$.
or......deaths......

To obtain the rate per week or per quarter it is necessary to remember the varying number of days in different months and quarters; and also that an exact year contains 365·24226 (say 365·25) days, and 52·17747 weeks. To obtain the weekly rate, multiply the number of births (or deaths) for the week by 1,000 and by 52·17747, and divide by the population ; and similarly for other periods. (See also Appendix.) Before calculating mortality statistics, it is the custom to deduct deaths in hospitals, etc., of persons whose previous residences were not in the same districts as the hospitals ; and to add on deaths taking place in out-lying institutions of persons who previously had lived in the district for which the calculation is being made. Such information is obtained from the death register. The weekly averages are sometimes compared with 'corrected averages': these are the average weekly deaths for the previous ten years raised so as to allow for the increase in population.

6. *The mean age at death* of a population is the sum of the ages at death divided by the deaths. This gives no information as to the health or sanitary condition of a people, as great infant mortality may reduce the age, though the health of the adults may be good. The mean age at death in England is about forty years.

7. *Probable duration of life* (*vie probable*) is the age at which a given number of children born into the world at the same time will be reduced to one half.

8. *Expectation of life, mean future, after-lifetime, mean duration of life* (*vie moyenne*) is the true test of the health of a people. It is the average length of time a person of any age may be expected to live. Tables have been constructed by Dr. Farr which show the expectation of life at any age.

Conclusions which may be drawn from the statistics supplied by medical officers of health: Death-rates calculated for very short periods are liable to accidental fluctuations, and are not of great value; numerous factors must be taken into account before saying that a death-rate is good or bad, and before instituting comparisons between the death-rates of different places. Regard must be had to the social conditions and occupations of the people, and especially to the *age and sex distribution:* thus among the poorer classes the death-rate of children is much higher than that of the better-off classes; or, again, as the average duration of life among women is greater than amongst men, the death-rate will probably be lower in a place where women predominate than where the opposite prevails; so, again, health-resorts may have their death-rates increased or diminished by the class of people frequenting them. In order to better compare rates, the Registrar-General at the census periods makes up a table showing the mean annual death-rate for each sex and age-period for the whole country (England and Wales) for the past ten years, and applies this to the population of every town and district, as given by the census, and thus forms a *standard rate* for each district. He then divides the mean annual death-rate of the country for the past decade by the standard rate of each district, and by this means obtains a factor by which the recorded death-rate of any year must be multiplied.

A *high birth-rate* need not necessarily be combined with a high death-rate, as was argued by Dr. Letheby: it is upon age distribution that both birth-rate and death-rate depend. The conclusion to be drawn from a high birth-rate is that the population contains a high percentage of young adults (whose mortality-rate is low), and consequently a low percentage of elderly people (with a high death-rate). Unfortunately, however, from improper feeding, maternal neglect and insanitary conditions generally, a high birth-rate is often accompanied by a high death-rate. The susceptibility of young children to diseases, especially those of zymotic origin, increases the death-rate, and, as there are fewer deaths among persons between the ages of fifteen and fifty-five than in those above or below these ages, the larger the proportion of the first class in a population, the lower will be the death-rate. The causes, however, it should be noted, come entirely under the class known as 'preventible.' It is usual to state the deaths of children under one year of age as so much per 1,000 registered births, rather than per 1,000 of estimated population, as the former is more likely to be correct; thus the mortality of infants under one year of age in England and Wales was calculated for 1888 to be 145 per 1,000 of the estimated population at that age, while per 1,000 births registered in 1888 it was only 137.

The average annual rate during the ten years (1879-88) was equal to 141 per 1,000 registered births: it varied in the large towns from 139 to over 200 (in Preston and Leicester), while in the chain-making district of Cradley Heath it is reported to have been as much as 500! In the third quarters of those years (when infantile diarrhœa was prevalent) the average was 156 per 1,000 in England and Wales; 206 in the large towns. The average death-rate per 1,000 living under five years of age is about 63 for both sexes, the rate being 68 for male, 58 for female children.

One quarter of these deaths is due to the zymotic class, the rest to diseases of the head and chest, abdominal tubercle and diarrhœa.

The death-rate from zymotic diseases should always be carefully reviewed, with the aim of determining the relation to defective sanitary arrangements; for, as Dr. C. E. Paget has pointed out (*Practitioner*, January, 1887), the incidence of measles, whooping cough, or scarlet fever bears a different interpretation to a high or frequently recurring death-rate from enteric fever or diphtheria. The latter shows unmistakably that the sanitary arrangements are defective, while the former indicates a failure on the part of the sanitary authority to control the spread of the disease by such means as isolation, disinfection, etc. Dr. Farr held that a sustained general death-rate of over 17 per 1,000 implies unfavourable sanitary conditions.

The average annual death-rate for the ten years, from the beginning of 1871 to the end of 1880 in England and Wales was :

| | |
|---|---|
| All causes ... ... ... | 21·27 |
| Zymotic diseases ... ... | 3·40 |

As a check upon the Registrar-General's method of estimating population, the number of births is sometimes taken as a basis of calculation ; in large populations this may be useful, but it is liable to fluctuate; less trustworthy are the figures obtained from the number of inhabited houses (multiply each inhabited house by 5). Both methods imply an intimate knowledge of the district.

The Education Department regards the number of children between the ages of three and thirteen as one-sixth of the whole population.

# APPENDIX.

## THE COMMONER ELEMENTS.

| Name. | Symbol. | Combining Weight. |
|---|---|---|
| Aluminium ... ... ... | Al | 27·5 |
| Antimony ... ... ... | Sb | 122 |
| Arsenic ... .. ... ... | As | 75 |
| Barium ... ... ... ... | Ba | 137 |
| Bismuth ... ... ... ... | Bi | 210 |
| Bromine .. ... ... ... | Br | 80 |
| Calcium ... ... ... .. | Ca | 40 |
| Carbon ... ... ... ... | C | 12 |
| Chlorine ... ... ... ... | Cl | 35·5 |
| Chromium ... ... ... | Cr | 52·5 |
| Copper ... ... ... ... | Cu | 63·4 |
| Cobalt ... ... ... ... | Co | 59 |
| Hydrogen ... ... ... | H | 1 |
| Iodine ... ... ... ... | I | 127 |
| Iron ... ... ... ... | Fe | 56 |
| Lead ... ... ... ... | Pb | 207 |
| Magnesium ... ... ... | Mg | 24 |
| Manganese ... ... ... | Mn | 55 |
| Mercury ... ... ... ... | Hg | 200 |
| Nitrogen ... ... ... ... | N | 14 |
| Oxygen ... ... ... ... | O | 16 |
| Phosphorus ... ... ... | P | 31 |
| Platinum... ... ... ... | Pt | 197·1 |
| Potassium ... ... ... | K | 39·1 |
| Silicon ... ... ... ... | Si | 28 |
| Silver ... ... ... ... | Ag | 108 |
| Sodium ... ... ... ... | Na | 23 |
| Strontium ... ... ... | Sr | 87·6 |
| Sulphur ... ... ... ... | S | 32 |
| Tin ... ... ... ... | Sn | 118 |
| Zinc ... ... ... ... | Zn | 65 |

## Thermometer Scales.

$$\frac{\text{Centigrade}}{5} = \frac{\text{Réaumur}}{4} = \frac{\text{Fahrenheit} - 32}{9}$$

$$F.^\circ = \frac{9\ C.^\circ}{5} + 32. \qquad C.^\circ = \frac{5\ (F.^\circ - 32)}{9}.$$

| | C. | R. | F. |
|---|---|---|---|
| Water freezes at ... ... ... | 0·0 | 0·0 | 32·0 |
| Water is at its maximum density at | 4·0 | 3·2 | 39·2 |
| Mean temperature for sp. gr., barometrical readings, etc. ... ... | 15·5 | 12·4 | 60 |

## Barometer.

Standard pressure = 760 millimetres = 29·9222 inches.
1 inch = 25·4 millimetres.

## Metrical Weights and Measures.

The Latin prefix indicates division, the Greek multiplication.

### *Length.*

1 metre = 39·37 English inches.
1 decimetre = 3·94 „ „
1 centimetre = 0·39 „ „
1 millimetre = 0·039 „ „
25·4 „ = 1·00 „ „
1 kilometre = 1000 metres = 1094 yards = ⅝ mile (nearly).
1·609 „ = 1 mile.

### *Capacity.*

1 decimetre cubed = 1 litre = 1000 cubic centimetres = 61 cubic inches = 35·3 cubic ounces = 0·22 gallon.
1 cubic centimetre (1 c. c.) = 0·061 cubic inch.

### *Weight.*

1 gramme = the weight of a cubic centimetre of distilled water at 4° C. (39°·2 F.) = 15·432 grains.
1 kilogramme = 1000 grammes = 2·2 lb. avoir.
1 square acre = 4840 square yards.
1 „ mile = 640 „ acres.
1 inch of rain on 1 square yard = 4·6 gallons.
1 „ „ 1 „ acre = 101 tons (by weight).

## Examples.

### *Water Supply.*

A town requires 12,460 gallons per day. What must be the size of the reservoirs to have four days' supply ?

6·23 gallons = 1 cubic foot.

∴ 12,460 ÷ 6·23 = 2,000 cubic feet, the amount required per day, × 4 = 8,000, the amount required for four days.

If $\frac{1}{8}$ inch of rain falls in 10 minutes, how much water does this give per square mile at the same rate ? State the result in cubic feet, gallons, and tons.

$\frac{1}{8}$ inch in 10 minutes = $1\frac{1}{2}$ feet in 24 hours.

1 square mile = (1,760 yards × 3)$^2$ = 27,878,400 square feet.

∴ 27,878,400 × $1\frac{1}{2}$ = 41,817,600 cubic feet.

41,817,600 × 6·23 = 260,523,648 gallons.

As 1 gallon = 10 lbs.

∴ 260,523,648 × 10 ÷ (112 × 20) = 1,163,048 tons.

### *Drainage.*

Given the amount of fall in a sewer, and the velocity to find the fall necessary for a greater or less velocity :

The known fall will be to the required fall as the square of the velocities are to one another.

*Example.*—A sewer has a fall of 1 in 200 with a velocity of 3 feet per second ; what fall should there be to give a velocity of 6 feet per second ?

Let $\frac{1}{x}$ = the required fall, then $\frac{1}{200} : \frac{1}{x} :: 3^2 : 6^2$

$\therefore \frac{1}{x} = \frac{1}{50}$ Answer : 1 in 50.

### *Calculation of Percentage Composition of a Substance from its Formula.*

*Method :*

Let $a$ = molecular weight of substance.

$b$ = weight of any one element in that molecule.

Then $\frac{100b}{a}$ = the percentage of that element.

*Example.*—Required the percentage of nitrogen in urea?

Urea = $CON_2H_4$.

$$\left.\begin{array}{l} C\ =12\times1=12 \\ O\ =16\times1=16 \\ N_2=14\times2=28 \\ H_4=\ 1\times4=\ 4 \end{array}\right\}=60 \text{ molecular weight.}$$

Then $\frac{100\times28}{60}$=46·67 per cent. of nitrogen.

The percentage being found, the amount of one element in a given quantity of a substance may be ascertained by proportion.

*Example.*—What weight of nitrogen is contained in 0·15 gramme of urea?

100 : 0·15 : : 46·67 : $x$ = 0·07 gramme.

*Specific Gravity of Gases.*

To find the sp. gr. of a gas, divide the weight of the gas by the weight of an equal quantity of air or hydrogen (whichever be taken as the standard of comparison).

A litre of air weighs 1·29 grains.

A litre of hydrogen weighs 0·0896 grains.

*Example.*—Find the sp. gr. of the atmosphere as compared with hydrogen.

$$\frac{1{\cdot}29}{0{\cdot}0896}=\text{sp. gr.}=14{\cdot}4.$$

*Example :*

| | | | | | | |
|---|---|---|---|---|---|---|
| A glass globe full of air weighs | | | | | 1272 67 grains. | |
| A | „ | „ | „ | $CO_2$ „ | 1279·27 | „ |
| A | „ | „ | empty | „ | 1260 | „ |
| ∴ Weight of air contained in globe | | | | | =12·67 | „ |
| and „ | $CO_2$ | „ | „ | „ | =19·27 | „ |

$$\frac{19{\cdot}27}{12{\cdot}67}=1{\cdot}52 \text{ sp. gr. of } CO_2.$$

*Correction of Volumes of Gases for Pressure.*

The standard pressure is 760 millimetres of mercury. The volume of a gas varies inversely as the pressure to which it is subjected (Boyle and Mariotte).

Let $a$=volume of gas,

$H$=original pressure,

$h$=final pressure,

then final vol.$=a\,\frac{H}{h}$

*Correction of Volumes of Gases for Temperature.*

All gases expand equally when heated through the same number of degrees, viz., $\frac{1}{273}$rd of the volume, at 0° C. for every degree Centigrade.

Let $a$=vol. of gas,
$T$=original temperature (° C.)
$t$=final temperature,

$$\text{then final vol.} = \frac{a\,(273+t)}{273+T}$$

*To correct for both pressure and temperature* the two formulæ are combined thus :

$$\text{Final vol.} = \frac{a\,H\,(273+t)}{h\,(273+T)}$$

The result may also be obtained by rule of three, wherefrom these formulæ are derived, as in this example : A glass globe holds 10 litres, if it is filled with oxygen at 0° C. under pressure of 760 mm., how much gas will escape when the temperature rises to 15° C. and the barometer falls to 752 mm. ?

$$\left.\begin{array}{l} 273+0 : 273+15 \\ 752 \quad : 760 \end{array}\right\} : : 10 : x = 10{\cdot}6617$$

$\therefore$ 0·6617 will escape.

*Ventilation.*

To determine the volume of pure air required per hour to maintain a standard of ·6 of $CO_2$ per 1000 (*i.e.*, ·4 initial + ·2 permissible respiratory impurity) in an inhabited room :

Let $e = CO_2$ evolved by each individual per hour.
$r$ = respiratory impurity permitted (·0002) or found per cubic foot.
$d$ = volume of pure air to be delivered.

Then $d = \frac{e}{r} = \frac{\cdot 6}{\cdot 0002} = 3000.$

*Examples :*

The total $CO_2$ in a room was 1·1 per 1000 (or ·0011 per cubic foot) ; in the open it was ·4 per 1000 (or ·0004 per cubic foot; find the volume of air actually supplied to the room.

Respiratory impurity is ·0011 − ·0004 = ·0007.

$$\therefore d = \frac{\cdot 6}{\cdot 0007} = 857 \text{ cubic feet per hour.}$$

The air of a room occupied by six persons, and containing 5,000 cubic feet of space, yields 7·5 parts of $CO_2$ per 10,000; how much air is being supplied per hour?

7·5 per 10,000 = ·00075 per cubic foot.

·00075 − ·0004 = ·00035.

$$\therefore d = \frac{\cdot 6 \times 6}{\cdot 00035} = 10300 \text{ total cubic feet per hour.}$$

Similarly *e* and *d* being known, *r* can be ascertained.

*Calculation of Cubic Space in Buildings.*

A circular ward, with a dome-shaped roof, requires to be measured; the diameter is 36 feet, the height to centre of dome is 18 feet, and the height of the walls is 12 feet. Find the floor space and total cubic contents. How many patients should be placed in such a ward?

Area = (Diameter)$^2$ × ·7854.
= 1017·8764 square feet.

Area × height = cubical capacity.

1017·8764 × 12 = 12214·5408 cubical capacity of cylinder irrespective of dome.

Cubical capacity of dome = area of base × height × $\frac{2}{3}$.
= 4017·5136.

Total cubical capacity = 16286 cubic feet.

To ascertain number of beds allowable, disregard the dome and divide the cubical capacity of lower part by 144, the number of square feet to be allowed to each bed this would give 7.

If only 72 square feet per head were allowed, the cubic feet per bed would only be about 900, which is too small for a hospital.

What is the greatest number of persons that should be allowed to sleep in a lodging-house dormitory 39 feet 6 inches long, 12 feet broad, height of room to apex of roof 15 feet 3 inches, of walls 9 feet? How many cubic feet will the room contain?

Area = 39·5 × 12 = 474 square feet.

The height is 9 feet for lower part, and $6\frac{1}{4}$ for the upper triangular part, of which half has to be taken in calculating cubic contents, giving

$$9+3\tfrac{1}{8}=12\tfrac{1}{8} \text{ feet.}$$

Total cubic capacity $=474\times12\frac{1}{8}=5747$ cubic feet.

Here the floor space nearly equals $\frac{1}{12}$th of the floor area as recommended.

Deduction has to be made from the above for furniture, bedding, etc., for which 30 feet per head may be allowed; as 300 cubic feet per head is the quantity required in common lodging-houses, 5,747 cubic feet must be divided by 300+30—this will give about $17\frac{1}{2}$. Two children under ten years of age count as one adult, therefore this room may contain seventeen adults and one child under ten.

*Food.*

How much cooked beef and bread is required to provide enough nitrogen and carbon per day in model proportion for a healthy adult in average work?

(1) Bread contains per ounce N 5 grains, C 120
(2) Beef „ „ N 15 „ C 120.
Let $x$ = amount of meat in ounces.
„ $y$ = „ bread „

Then, as 300 grains of nitrogen are necessary, the amounts of that element in the bread and beef must equal that quantity; and so with the carbon (4,800). Thus equations may be formed:

(1) $15x + 5y = 300$
(2) $120x + 120y = 4{,}800$
multiply (1) by $8 = 120x + 40y = 2{,}400$
subtract from No. (2) $120x + 120y = 4{,}800$
then $80y = 2{,}400$
$y =$ 30 oz. of bread.

Substitute the value for $y$, viz., 30 in one of the equations, and $x$ will be found to be 10 oz. of cooked beef.

How much oatmeal, milk and butter should be in a model diet? Are the salts in proper proportion?

| | Albumen. | Fats. | Carbohyd. | Salts. |
|---|---|---|---|---|
| Oatmeal | 12 | 6 | 60 | 3 |
| Milk | 4 | 3 | 5 | 0·7 |
| Butter | — | 84 | — | 2 |

Let $x$ = oatmeal, $y$ milk, and $z$ butter.

It must be kept in mind that the figures given in the above analysis are *percentages*.

(1) $\frac{12x + 4y}{100} = 4{\cdot}5$ oz. (the standard amount of albuminoids).

(2) $\frac{6x + 3y + 84z}{100} = 3$ oz. (the standard amount of fat).

(3) $\frac{60x + 5y}{100} = 14{\cdot}25$ (the standard amount of carbohydrates).

On solution of these equations, the quantities will be found to be :

Oatmeal, $19\frac{1}{6}$ oz. ; milk, 55 oz. ; butter, $\frac{1}{4}$ oz.

To find the salts :

| | | | | |
|---|---|---|---|---|
| Oatmeal | contains | 3 | per cent. | $\therefore$ 19·17 × 3 ÷ 100 = ·5751 |
| Milk | ,, | 0·7 | ,, | $\therefore$ 55 × 0·7 ÷ 100 = ·385 |
| Butter | ,, | 2 | ,, | $\therefore$ 0·238 × 2 ÷ 100 = ·0047 |
| | | | | ·9648. |

The standard being 1 oz., this is nearly the correct proportion of salts.

How much potential energy (expressed in foot-tons) will be developed by 5 oz. oatmeal, $\frac{1}{2}$ lb. cooked meat, 4 oz. bread, and 1 pint milk when oxidized in the body ?

This may be found from the following table, in which the food is taken as being in its usual state, not water-free, theoretically :

| | | | | Foot-tons. |
|---|---|---|---|---|
| One ounce of | uncooked beef | yields | ... | 50 |
| ,, | cooked meat | ,, | ... | 160 |
| ,, | dried bacon | ,, | ... | 179 |
| ,, | bread | ,, | ... | 88 |
| ,, | oatmeal | ,, | ... | 130 |
| ,, | potatoes | ,, | ... | 33 |
| ,, | butter | ,, | ... | 339 |
| ,, | eggs | ,, | ... | 68 |
| ,, | milk (cows') | ,, | ... | 27 |

Therefore :

| | | Foot-tons. |
|---|---|---|
| Five ounces oatmeal | $=130\times 5$ | $=650$ |
| Eight ounces cooked meat | $=106\times 8$ | $=848$ |
| Four ounces bread | $=88\times 4$ | $=352$ |
| Twenty ounces milk | $=27\times 20$ | $=540$ |
| | | 2,390. |

*Exercise.*

How much work is done by a man walking at ordinary velocity a distance of 15 miles on an ascent of 1 in 200, the weight of the man and what he carried being 12 stone 8 lb. ? State the answer in foot-tons.

Walking 3 miles an hour is equivalent to raising $\frac{1}{20}$th of his weight through the distance walked.

Work done in walking 15 miles along a level road. $\Big\} = \frac{1}{20} \times \frac{(W+W')D\times 1760\times 3}{2240}$
$= 311\cdot24285$ foot-tons.

Find the number of feet rise in 15 miles on the ascent of $\frac{1}{200}$—this will give 396 feet up which he carries his whole weight $\therefore \frac{176}{2240} \times 396 = 31\cdot1147$ foot-tons.

The answer, 342·35758 foot-tons, is got by adding the two sets together.

A man weighs 160 lb. in his clothes, and carries a hod of bricks 40 lb. in weight up a ladder 30 feet high, 100 times a day. What amount of work does he do ? And what would it be in miles walked on a flat surface at the rate of 3 miles an hour ?

$$\text{Work done} = \frac{(200 \text{ lbs.}) \times 300 \text{ (ft.)} \times 100 \text{ (times)}}{112 \times 20 \text{ (to bring to tons)}}$$
$$= 267\cdot85 \text{ foot-tons.}$$

$$\therefore \frac{267\cdot85 \times 112 \times 20}{1760 \times 3} = \frac{1}{20} \times 200 \times D.$$
$$\therefore D = 11\cdot363 \text{ miles.}$$

Care must be taken in these questions to see that tons and pounds or feet and miles are multiplied together.

*Statistics.*

At the last census a town has a population of 10,000, the death-rate is 20 per 1,000, the birth-rate 30 per 1,000, assuming that these rates will remain constant, what should be the population of the town in 1891?

The rate of increase is 10 per 1,000, the difference between the rates; this gives an increase per unit of ·01, *i.e.*, at the end of a year 1 person becomes 1·01; this ratio may also be found by dividing 1,010, which is the second in the series by the first number, 1,000, as the population proceeds by geometrical progression: to find the population at the end of any year multiply the population by the ratio multiplied by itself as many times as there are years from the last census to the beginning of the year in question, thus for ten years as required it will be:

$$10{,}000 \times 1{\cdot}01^{10-1} = 10{,}000 \times 1{\cdot}104622, \text{ etc.} = 11{,}046.$$

One district of a town has a population of 150,000, with a death-rate of 21 per 1,000 per annum, and another district of the same town has a population of 20,000, with a death-rate of only 15. Show by calculation what is the death-rate of the combined districts?

This is not solved by simply adding the death-rates and dividing by 2, but by finding the proportional part that each bears to the whole population. Thus fractions are formed, the denominator being the total of the populations, the numerators being the separate district populations; thus in the above question 170,000 will be the total population:

$$\therefore \left(\frac{150{,}000}{170{,}000} \times 21\right) + \left(\frac{20{,}000}{170{,}000} \times 15\right) = 20{\cdot}39.$$

In a certain town the estimated population in 1889 was 208,710; the deaths for the week ending July 13 were 88 (5 of which were deaths of non-residents); there were 18 deaths of children under 1 year of age; 10 persons died from zymotic diseases; the births for the same period numbered 130.

Find the annual death-rate per 1,000 of population (supposing this ratio to be maintained throughout the year).

Find the rate from zymotic diseases, and their percentage to total deaths.

Find the death-rate below 1 year per 1,000, and compare it with the births.

Deduct non-residents, leaving 83 deaths.

Population, 208,710 ÷ 52·17747 weeks = 4,000 the weekly population.

Then the death-rate $= \frac{83 \times 1,000}{4,000} = 20{\cdot}75$ per 1,000 per annum.

Zymotic diseases $= \frac{10 \times 1,000}{4,000} = 2{\cdot}5$ per 1,000 per annum.

$\frac{10 \times 100}{83} = 12{\cdot}049$ per cent. of total deaths.

Death-rate under 1 year $= \frac{18 \times 1,000}{4,000} = 4{\cdot}5$ per 1,000 per annum.

Compared with births $= \frac{18 \times 1,000}{130} = 138{\cdot}46$ per 1,000 births

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