SOLUTIONS TO THE QUESTIONS

SET AT THE

MAY EXAMINATIONS

OF THE

SCIENCE AND ART DEPARTMENT.

1884 TO 1886.

HYGIENE.

WITH

HINTS AND NOTES

BY J. H. E. BROCK,

Doctor of Medicine; Bachelor of Surgery; Diplomate of Public Health of the University of London; Fellow of the Royal College of Surgeons of England; Queen's Medallist for Physiology; Assistant Examiner in Hygiene, Science and Art Department.

LONDON:

CHAPMAN AND HALL, LIMITED,

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CONTENTS.

HYGIENE.

1884.

ELEMENTARY.

1. *Explain in detail why it is necessary to change the air of an inhabited room.*

1. During respiration certain changes take place in the air, which cause the inspiration of the air which has once passed through the lungs to be detrimental to health. Taking the composition of pure air to be 79 per cent of nitrogen, 20·9 per cent of oxygen, and ·04 per cent of carbonic acid, together with an amount of moisture varying with the temperature, it is found that the following differences occur in expired air, viz., the oxygen has fallen from 20·9 per cent to 16 per cent, the carbonic acid has increased from ·04 per cent to 4·7 per cent, that is by 120 times, and the expired air has become saturated with moisture, and contains foul organic matter. Of all these changes, the addition of the organic matter is the most important, for it is upon this that the injurious effects of expired air depend.

Pure air containing as much as 5 to 10 per cent of carbonic has been breathed with safety, but air which contained as little as ·9 per cent of carbonic acid, but was vitiated by the organic matter of respiration, was found by the late Dr. de Chaumont to be very harmful to health and most offensive to breathe.

2. *What are the Uses of Food? What are the 'food substances' or proximate constituents of Food? Do any foods contain them all?*

2. The uses of food are :

(i.) To repair tissue waste.

(ii.) To supply heat for the maintenance of the body temperature and energy for the performance of vital functions.

The 'food substances' are 'proteids' and other nitrogenous bodies, carbohydrates, fats, salts, and water.

The following foods contain all the above food substances :— milk, wheat, barley, oats, maize, millet, peas, lentils, cabbage, potato.

3. *What is the importance of cleansing the skin? What are the results of want of cleanliness?*

3. It is important to cleanse the skin because waste products are constantly accumulating on its surface and in its pores, which, if not removed very soon, interfere with its functions, become causes of disease themselves, and favour the growth of parasites on its surface.

The chief results of uncleanliness are—

(i.) Clogging of the sweat and sebaceous glands; the former, by checking perspiration, throws additional work on the kidney, which if not equal to the tax of removing its own waste and that of the skin also, becomes the seat of organic disease. Retention of sebaceous secretion causes the appearance of little black dots, so frequently seen on the surface of the skin, which are known as 'comedones.' In some cases the retained secretion produces a cyst.

(ii.) An accumulation of epithelial scales on the skin causes 'scurf.'

(iii.) Development of vegetable and animal parasites.

(iv.) The skin loses its delicate susceptibility to variations of temperature, and consequently people who are habitually uncleanly in their person are more liable to the harmful effects of cold than those who are more careful.

4. *How are soils classified for hygienic purposes? Which are the most healthy soils? Why is it important that the soil under houses should be drained?*

4. Different kinds of soil—

i. Granite, metamorphic and traprock.
ii. Clay slate.
iii. Magnesian limestone or dolomite and other limestones.
iv. Sandstones.
v. Gravels.
vi. Chalk.
vii. Sands.
viii. Alluvial—clays and marls.
ix. Marsh.
x. Made soils.

Of these the granite, metamorphic and traprock, and clay-slate being impermeable are nearly always healthy. Sandstones, gravel, and chalk are good if not underlaid by clay, which tends to make them damp. Sandy soils, if they do not contain much organic matter, are healthy, as are also limestones.

Alluvial, marsh, and made soils should be always avoided.

Drainage of the soil is of importance in keeping the house free from damp, and therefore saving its occupiers the chance of contracting such diseases as catarrhs, rheumatism, neuralgia, phthisis, malaria, &c.

5. *Why are young children so susceptible to cold? What rules would you lay down about their clothing?*

5. Young children are more susceptible to cold for two reasons—

(i.) Their metabolic processes or tissue changes are more active, and, therefore, the loss of heat is correspondingly greater than in the adult.

(ii.) Relatively to their size they expose a larger surface for radiation of heat.

Children should always be warmly and sufficiently clad, and on no account should they be left with bare arms and legs under the impression that they will thus become 'hardened' to the cold.

In cold weather wool should be worn next the skin, as, being a bad conductor, it minimises the loss of heat from the body, while, from its porous texture, it allows of free exchange of air. Clothing should be changed according to the temperature and not with reference to the particular season.

6. *How is meat changed by the process of boiling in water? What rules would you observe in boiling a joint?*

6. The effect on the meat depends on the method of boiling. If plunged directly into boiling water coagulation of the albuminoids on the surface of the meat takes places, by which an impermeable layer is formed; and much of the salts, extractives, gelatine, &c. are prevented from passing into solution in the water and are preserved in the meat. If the meat is put into cold water, and the latter gradually brought up to boiling-point, the salts, gelatine, and extractives are removed before the coagulation of albuminoids occurs, and much of the flavour of the meat is thus lost. The effects of boiling are, therefore, to coagulate

the albuminoids of meat, to loosen the muscular fibres, and to dissolve out salts, extractives, dextrine, and gelatine. To boil meat, it ought to be plunged at once into boiling water and kept at the boil for a few minutes, and then the temperature of the water maintained at about 180° Fahr.

7. *What are the characteristics of a good drinking water? What effects are ascribed to the drinking of water contaminated by sewage?*

7. Good drinking water should possess the following characteristics:—It should be clear and odourless; should have a bluish-white or grey colour when looked at in a 2-feet tube; its taste should be fresh and aërated, neither salt nor sweet; and it should have no suspended matter in it.

The effects which have been traced to water contaminated by sewage are:—Diarrhœa, dysentery, typhoid fever, cholera, parasitic diseases, such as tape-worms, round-worms, thread-worms, &c., and, it is said, yellow fever.

8. *What is the composition of cocoa? Compare it with coffee as an article of food.*

8. Cocoa:
- (i.) Fat, 45 to 50 per cent.
- (ii.) Theobromine, 1·2 per cent.
- (iii.) Albuminoids, 13 to 18 per cent.
- (iv.) Salts, especially acid phosphate of soda.
- (v.) Starch.
- (vi.) Volatile oil.

Cocoa resembles coffee in possessing an alkaloid, theobromine, and a volatile oil; but containing a large amount of fat and nitrogenous substances, it is very far superior to coffee in nutritive value, and is used in some parts of the world as a food.

9. *What are the causes of natural ventilation? How may ordinary sash windows be used to ventilate rooms properly.*

9. The causes of natural ventilation are:

(i.) The winds, which in this country move at a rate varying from one to nine miles an hour. They may act directly by driving the air out of a room, or indirectly, as when the wind blowing over the top of a chimney-pot produces a diminution of pressure in the chimney and, consequently, an up-draught.

(ii.) The diffusion of air, by which the composition of the air in a room is rendered uniform.

(iii.) Movements of air caused by differences in weight due to changes of temperature. Heated air, being light, rises to the top of a room and tends to pass out, while the cold air replacing it falls downwards towards the floor.

Ordinary sash windows may be used to ventilate rooms by one of the following methods :—

(*a*) By Hinche's Bird's plan. The lower window being drawn up a few inches, a piece of wood is accurately fitted into the space left below. Air can now enter between the two windows.

(*b*) By Tobin's plan of cutting out pieces of wood from the woodwork at the lower part of the upper window.

(*c*) By the insertion of Cooper's ventilators into the upper pane.

(*d*) By substituting louvre windows for the upper pane.

10. *Explain the movements of the air at the sea-border. Of what importance are these movements?*

10. At the sea-border two kinds of movement of the air take place. During the day the breeze blows from the sea towards the land, while in the night the reverse occurs. These changes are thus brought about :—The land being the better absorber of heat becomes more heated by the sun than the water. The air above the land being, therefore, hotter than that over the sea, the cold air over the ocean rolls in towards the land and produces the sea-breeze. The earth, although a better absorber of heat, radiates it more quickly than the water ; and consequently during the night, becoming cooler than the ocean, produces a breeze blowing exactly in the opposite direction to that during the day. This is the land-breeze.

These breezes produce two effects :

(i.) They make the days cooler and the nights warmer, and thus tend to equalise the temperature.

(ii.) They effect an exchange of air and purify the atmosphere.

11. *What influence does exercise exert over the muscles, the circulation of the blood, and the nervous system?*

11. Work stimulates tissue change in a muscle and augments

its products of oxidation or waste material. If periods of rest are allowed this waste matter is removed and fresh tissue is formed, but to such an extent that the new tissue exceeds the old in amount, so that the muscle grows with exercise. Too much or too little exercise causes wasting and flabbiness of muscles. With moderate exercise the heart is stimulated, so that it beats more quickly and strongly, and blood circulates more freely in the more distant parts of the body. After exercise the heart slows to somewhat below its normal rate of action. If the exercise be too violent the pulse becomes small, frequent, and thready. Prolonged over-exercise causes dilatation and hypertrophy of the heart-wall and even disease of the valves.

Exercise facilitates the return of blood through the veins to the heart.

The exact influences of exercise on the central nervous system is unknown. It probably acts in the same way as on other organs, and, in moderation, is beneficial. Although many athletes are men of high mental culture, it is a familiar fact that men who shine in sport are often weak at their books, a result which is probably to be explained by their having cultivated the body to the almost total neglect of the mind.

12. *Describe a method of inducing artificial respiration.*

12. Silvester's method. Place the patient on his back, slightly raise the head, and draw forward the tongue. Grasp the arms just above the elbows and draw them slowly upwards and outwards above the head so as to drag upon the pectoral muscles. Then bring the arms down again slowly to the sides, while at the same time an assistant pushes the lower ribs and diaphragm upwards and inwards. These operations should be repeated about fifteen times a-minute.

1884.

ADVANCED.

21. *What amount of fat is contained in an average diet? How is it disposed of in the system? What are its effects on the intestinal canal?*

21. An average diet should contain about 3 ounces of fat.

By the gastric juice some of the envelopes of the fat cells are dissolved. When the fat reaches the small intestine it undergoes saponification by the pancreatic and biliary secretions, and the fat is emulsified. By the villi of the small intestine the fat is absorbed, and finds its way into the lacteals, lymphatics, and, finally, the thoracic duct, by which it is conveyed into the circulation. Some of the fat is stored up as adipose tissue, some is deposited in the liver, and some is used at once to supply heat to the body; the final products of its oxidation being carbonic acid and water.

The fat which escapes absorption is passed by the fæces unchanged. During its passage along the gut the fat lubricates the interior of the bowel, and stimulates its peristaltic action.

22. *What are the advantages and disadvantages of the water carriage system of excrement removal?*

22. The advantages of the method are :—

(i.) That it forms an easy, rapid, and cleanly method of removing the excreta from the house.

(ii.) It obviates the necessity of collecting earth and other deodorants and disinfectants.

(iii.) It prevents the danger and annoyance of large accumulations of excreta about the house.

Its disadvantages are :—

(i.) Unless skilfully carried out, there is danger of escape of sewer air into the house from faulty joints, unsealed traps, and unventilated soil pipes.

(ii.) It may, from bad arrangement, contaminate the drinking water.

(iii.) The great drawback of a water carriage system is the disposal of the watery sewage after its removal. Unless properly carried out this may become a serious danger.

23. *How is the amount of carbonic acid in the air ascertained? Of what use is the information thus obtained?*

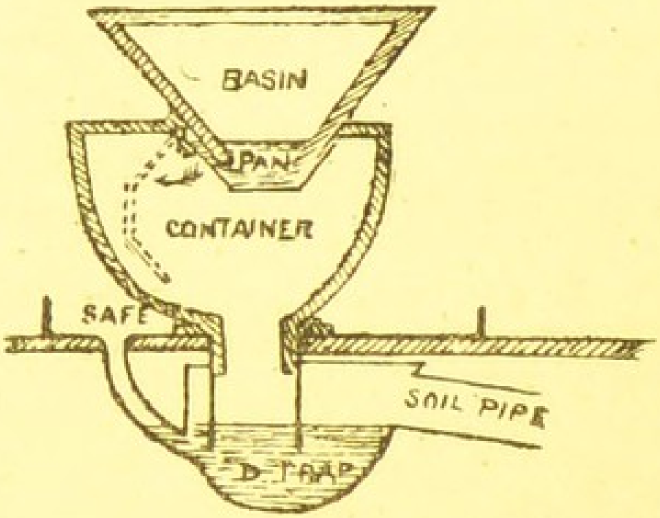
23. Take a glass jar, provided with an accurately fitting cork, and of about 4½ litres capacity. Fill the jar with water, and, having taken it to the place of experiment, remove the cork and invert the jar. The water flowing out is replaced by the air of the place to be examined. Then take a solution of baryta water and determine its causticity. Having ascertained this, put 60 c.c. of this baryta solution into the jar, cork it, and shake up vigorously. Leave the jar to stand for from 12 to 24 hours. At the end of that time the baryta solution will be found to be turbid, owing to the formation of carbonate of baryta, by which the causticity of the solution will have been diminished. 30 c.c. of this solution are taken out of the bottle, and their alkalinity again determined. Deduct the alkalinity of the 60 c.c. as now determined from the amount which was ascertained before the experiment began, and multiply the difference by the factor ·795. Call this a=total CO^2 in jar in c.c. Deduct from the capacity of the jar 60 c.c., the room occupied by the baryta solution. Let this be b. Divide a by b, and the result will be the quantity of CO^2 per litre or volumes per 1000 of the air.

The determination of the carbonic acid of the air of a place occupied by human beings is of importance, inasmuch as the quantity of this gas in the atmosphere is a good index to the amount of the foul organic matter of respiration which is present.

24. *Describe the construction of a 'pan' water closet, and of a D trap, giving sketches. Are they good or bad forms of sanitary apparatus? Give your reasons.*

24. The pan closet consists of a conical-shaped basin, having its outlet closed by a metal pan, usually made of copper and lined with tin, and by which a small quantity of water is retained in the basin. This pan is, by means of a wire, placed in connexion with the plug. By pulling up the plug the pan is swung back, and its contents are shot into an iron box, called the container. From the container a pipe leads into a leaden D trap, from the side of which the soil pipe comes off.

The D trap consists of a leaden box shaped like the letter, the round part of the D being downwards, ᗜ. Into the top of this trap the pipe from the container leads, and from the upper and lateral part of the trap comes off the soil pipe.



The objections to the pan closet are :—

(i.) The water is supplied to the basin by a spreader and not by a flushing rim, so that there is a liability to foul matter being left behind.

(ii.) The pan rapidly becomes coated with filth, and sometimes is perforated. In the latter case sewer air escapes into the house.

(iii.) The container becomes coated on its sides by a dirty slime, of exceedingly disagreeable odour, so that every time the plug is pulled up a gust of foul air escapes.

(iv.) The D trap favours the accumulation of paper and fæcal matter.

(v.) As a rule the soil pipe is unventilated. The 'pan' closet is probably the worst type of closet ever invented.

The D trap is a very bad form of trap, and has only one advantage, *viz.*, that it is not easily unsyphoned. This single advantage, however, is not sufficient to compensate for its other serious drawbacks.

25. *In what articles of clothing and of decoration is arsenic sometimes found? What are its injurious effects, and under what circumstances are they most likely to appear?*

25. Arsenic is found in paints, papers, and articles of dress, coloured with Scheele's green, emerald green, and some of the aniline dyes, especially the red. Although green is the colour most often associated with the presence of arsenic, many browns, blues, mauves, and greys yield the metal in large quantities. Arsenical dyes are often used to colour stockings, artificial flowers, and muslins. The most frequent symptoms of arsenical

poisoning are redness and running from the eyes, headache, vomiting and diarrhœa, and abdominal pain. Poisoning by arsenic is most liable to occur when the articles containing it become damp. By the action of water on the arsenic, arseniuretted hydrogen is formed. which, being volatile, escapes into the air, and develops its poisonous effects in those exposed to its inhalation. It is said that the mixture of starch and arsenic will develop arseniuretted hydrogen. As distemper may contain starch and arsenic, the possibility of arsenical poisoning is easy.

26. *Describe the usual method for determining the amount of moisture in the air. How is the amount generally expressed?*

26. The amount of moisture present in the air may be obtained by drawing a known quantity of air through anhydrous phosphoric acid and weighing. For hygienic purposes the amount of moisture in the air is arrived at by finding the dew-point.

This is most usually done by the dry and wet bulb thermometres and Mr. Glaisher's factors. Take the readings of the two thermometers, and then deduct the reading of the wet bulb from the dry bulb thermometer. Look in Glaisher's table for the factor which stands opposite the dry bulb temperature, and multiply it by the difference obtained above. Deduct this product from the temperature of the dry bulb, and the result is the 'dew-point.'

Taking 100 as complete saturation, the amount of aqueous vapour in the air is usually expressed in percentages of saturation. The percentage of aqueous vapour can thus be determined.

In a table of tensions of aqueous vapours find the tension at the temperature of the dry bulb thermometer. Let this $= t$.

Let the tension of aqueous vapour at the dew-point, determined above, $= t'$.

Let $x =$ percentage of aqueous vapour to be found.

Then $t : t' :: 100 : x$.

27. *What is meant by hereditary tendency? What diseases are most markedly hereditary? What precautions should be taken against hereditary diseases?*

27. By hereditary tendency is meant a predisposition by inheritance of an individual to exhibit certain idiosyncrasies, or to contract certain diseases.

The diseases most markedly hereditary are : Cancer, phthisis, gout, rheumatism, hæmophilia. Nervous diseases such as, epilepsy, megraine, chorea, pseudohypertrophic paralysis, loco-motor ataxy, &c. Diabetes.

A person liable to hereditary disease, besides attending to general hygienic conditions, should avoid habits most liable to generate the particular disease to which he has a tendency. Some diseases, such as gout, rheumatism, phthisis, may with care be kept at bay ; while others, especially diseases of the nervous system, may attack an individual however careful he may have been.

28. *Under what conditions do marsh diseases appear? What are the chief characters of these diseases? How may they be prevented?*

28. The conditions which are usually present when marsh diseases are rife are : (i.) Decaying vegetable matter ; (ii.) Moisture ; and (iii.) A temperature usually about 70° Fahr. or higher.

Marshes are usually below the level of surrounding districts ; their soils are water-logged ; and they have a luxuriant vegetation of their own. The water of a marsh may be derived either from the rain, springs, rivers, or from the sea.

Marsh diseases, although most common in marshy districts, may appear in the absence of any marsh, as from the simple upturning of the ground and on the rocks at Hong Kong.

Marsh diseases assume one of two types, either intermittent or remittent, the former being the more common. They are endemic, not communicable, predispose to subsequent attacks, and are of indefinite duration.

Prevention of marsh disease.

(i.) *Treatment of the Country.*—Consists either in inundating the marsh and making it a lake, or in draining the subsoil.

(ii.) *Of the People.*—They should live in high houses, the windows of which should turn away from the direction of the prevailing wind off the marsh. They should sleep in the upper rooms of the house, and avoid sleeping on the ground. They should not drink the marsh water, should eat their food well cooked, and be warmly clad. Alcohol has no effect in the prevention of malarial disease. People living in marsh districts should take occasional courses of quinine.

1885.

ELEMENTARY.

1. *What is the normal composition of the air? How is it affected by the respiration of human beings?*

1. In 100 parts the normal composition of the air by volume is: Nitrogen, 79; oxygen, 20·9; carbonic acid, ·04; traces of ozone, ammonia, nitrates, &c., and a quantity of moisture varying with the temperature.

By respiration the following changes take place:—The oxygen is reduced from 20·9 to 16; the carbonic acid is increased from ·04 to 4·7; the expired air is saturated with moisture, and has a large quantity of foul organic matter added to it. The nitrogen remains practically unchanged.

2. *How is drinking water likely to be contaminated* (i.) *in wells,* (ii.) *in cisterns?*

2. (i.) In wells:

(*a*) Taking the well as a centre, every well drains an amount of land around it equal to four times its depth. Any excretal matter, organic, and other refuse on the surface of this area, together with the mineral impurities of the soil, are therefore liable to be washed into the well.

(*b*) By the overflow of cesspools; or by the faulty construction of these receptacles, which, instead of being properly constructed and water-tight, may allow the liquids of the sewage to drain away into the surrounding soil. Should the well and cesspool be so placed that the direction of flow of the subsoil water is from the latter towards the well, pollution of the well becomes a certainty.

(ii.) In cisterns:

(*a*) Through dirt, rubbish, and dead animals dropping into the water. Cisterns which have been left uncleaned for years will accumulate a store of filth, which is often truly marvellous.

(*b*) From the material of which the cistern is made. If of lead, water containing a large amount of oxygen or of nitrites acts as a solvent of the metal. If of galvanised iron, *i.e.*, iron with a coating of zinc, should the zinc become rubbed off, electrolytic action is set up, and zinc passes into solution. Lead may also get into the water should the latter be stored in slate or stone cisterns, as red lead is often used for the joints.

(*c*) Through the cistern being furnished with a standing waste pipe, which, instead of opening outside, is carried into the soil pipe or D trap of a pan closet.

Or the spindle-valve covering the opening of the pipe which supplies the closet may be enclosed in a ventilating pipe which opens under the cover of the cistern.

3. *What are the reasons for cooking food? How should a joint be roasted, and why?*

3. The reasons for cooking food are:

(i.) The food becomes softer, looser in texture, and more digestible.

(ii.) It prevents the possibility of human beings contracting contagious diseases from animals, being injured by products of putrefaction, or of becoming infested with parasites.

(iii.) The food becomes more palatable, and is more pleasant to the eye.

In roasting, a joint should first be placed close to a brisk fire, and kept there for ten to fifteen minutes, until the proteids on the surface of the meat have coagulated, so as to keep the salts and extractives in the meat. It should then be cooked by a slower fire until done through. It is said a joint requires about fifteen minutes for every pound weight, in roasting.

4. *Explain the importance of bodily exercise. Why is rest necessary?*

4. A certain amount of bodily exercise is absolutely essential to health. With a proper amount of exercise the healthy nutrition and growth of all the tissues and organs of the body is stimulated. Too much or two little exercise impedes growth.

By exercise, excretion of waste products of the body is accelerated.

Rest is quite as essential to the welfare of the body as exercise.

During rest, the tissue waste which took place during exercise is repaired, and the growth of the body promoted.

5. *Why is salt a necessary food? Whence is it obtained? What important mineral salts are contained in foods?*

5. Salt enters into the composition of the blood, and is found in every fluid and tissue of the body. It is, therefore, an important constituent of the animal organism, and its supply is essential to health. It is, moreover, a condiment.

Salt is obtained either by evaporating or freezing sea-water; or from brine springs; or from salt lakes; or it is obtained as rock-salt from beds of salt deposited in the earth.

The other important salts of the body are those of potash and magnesia, phosphate of lime, and iron.

6. *What is meant by 'hard' and 'soft' water? Which is better for domestic use, and why?*

6. 'Hard' and 'soft' are terms applied to waters according to the quantity of lime and magnesium salts which they hold in solution. Waters containing large amounts of these salts are said to be 'hard,' while those which have small quantities of them are termed 'soft.' Two kinds of hardness are distinguished, viz., temporary and permanent. Temporary hardness is due to carbonate of lime; permanent hardness to sulphate and chloride of calcium, and magnesium salts. The temporary hardness is got rid of by boiling, for by this the carbonic acid, which holds the carbonate in solution, is driven off, and the salt is thrown down. Hard waters do not readily form a lather with soap, because the calcium and magnesium which they contain first combine with the fatty acids of the soap before the lather can be formed. It will thus be seen that for domestic use hard waters entail a wasteful expenditure of soap. Moreover, it is a well-known fact that hard waters do not make such good infusions of tea as the softer varieties.

Grooms will not use hard water for washing horses, as it makes the coat staring and rough.

7. *How can the external air be admitted into rooms without producing draughts* (i.) *through the windows,* (ii.) *through holes in the walls?*

7. (i.) Through the windows:

(*a*) By Tobin's method of cutting out pieces of the woodwork from the lower part of the upper window.

(*b*) By Hincke's Bird's method of raising the lower window a little, and closing the aperture so formed by an accurately fitting piece of wood.

(*c*) By Cooper's ventilator, which consists of boring five holes in the pane of the upper window concentrically around a pivot on which rotates a glass plate, in which there are also five holes, which can be made to correspond or to alternate with those in the pane, and thus to admit an amount of air suitable to the taste of the occupier of the room.

(*d*) By substituting louvre ventilators for the upper pane.

(ii.) Through holes in the walls:

(*a*) By cutting a hole in the upper part of the wall, covering its exterior with a wire gauze, and placing in its inner side a piece of wood fixed to its lower border and sloping obliquely upwards in the direction of the ceiling. By this means the air is first sent upwards towards the ceiling, and thus the possibility of draught on the heads of people in the room is prevented.

(*b*) Based on the same principle is the Sherringham Valve, which consists of a metal plate provided with a check on each side, and furnished with a string and weight passing over a pulley, by which the valve can be open or shut at pleasure.

(*c*) By Tobin's tube, which is made up of a horizontal and a vertical part, the former opening outside to the air, and the latter running up the side of the wall for a distance of five or six feet, and terminating by a funnel-shaped aperture.

8. *How much air is necessary for each person per hour? And why?*

8. Every adult person requires 3000 cubic feet of air per hour. Each adult during an hour exhales ·6 cubic foot of carbonic acid. Pure air contains in every 1000 cubic feet ·4 cubic foot of carbonic acid.

It was found by the late Dr. de Chaumont, that the air of a room which contained more than ·6 cubic foot of carbonic for every 1000 cubic feet of air, felt stuffy, and was injurious to health to breathe. Hence, as 1000 cubic feet of pure air contain ·4 cubic foot of carbonic acid, the limit of respiratory impurity is ·2 cubic foot more. Now it has been found that the average amount of carbonic acid produced by each adult per hour, is ·6 cubic foot; that is, three times the limit of respiratory impurity. Therefore, 3000 cubic feet of air will be the quantity of air necessary per head per hour.

9. *How do winds act as ventilating agents? How may their action be utilised?*

9. Winds act as ventilating agents in two ways. They either drive the air directly out of a room, or they may indirectly cause the air to be drawn through a room. The direct action of the wind is utilised in all methods of natural ventilation, and also in Sylvester's plan, which consists in having a cowl constantly turned in the direction of the wind, down which the air passes and is conducted by a tube into a chamber, where it is warmed, and then distributed to other rooms.

The indirect action of the wind in ventilation is seen as it blows over the tops of chimneys, when it produces a diminution of pressure in the chimney, and so favours an up-draught.

10. *Compare wool and cotton as materials for articles of clothing.*

10. Wool conducts and radiates heat much more slowly than cotton, and is a far readier absorbent of moisture. From its former qualities it is a much better protective from the cold; while from the latter, its use is better calculated to prevent colds and chills, as it quickly absorbs perspiration, and yet does not present a wet surface to the skin.

11. *What influence has* (i.) *elevation above the sea* (ii.) *distance from the sea on the climate of a place?*

11. (i.) Elevation above the sea. The air is (*a*) colder; (*b*) drier; (*c*) less dense; (*d*) purer, and contains more ozone; (*e*) the temperature is hotter in the direct rays of the sun; (*f*) there is more light.

(ii.) Distance from the sea makes the place (*a*) drier; (*b*) more subject to extremes of heat and cold.

12. *A person has swallowed oil of vitriol; what would you do?*

12. In a case of poisoning with a corrosive liquid like sulphuric acid, the stomach pump should on no account be used, nor should an emetic be administered. Either of these treatments increases the risk of perforation of the stomach, which is already in this case sufficiently great. The patient should be given a good drink of lime water, or from one to two drachms of the oxide of magnesia. The carbonates of these metals should not be used, as carbonic acid would be given off on contact with the acid, and would still further augment the distress and danger of the patient.

1885.

ADVANCED.

21. *Discuss the value of gelatine as an article of food. How much carbon, and how much nitrogen are contained in an average diet?*

21. An animal fed on gelatine alone will very soon emaciate and die of starvation; nor can life be maintained on gelatine with carbohydrates and fat. It has been found, however, that an animal which is losing flesh from a deficiency of nitrogenous food, will thrive if the deficit of nitrogen be made up in the form of gelatine. It seems probable that gelatine does not supply tissue waste, but is used up immediately in the blood for the wants of the organism. It is in fact useful for supplying a store of 'floating nitrogen.'

An average diet should contain 300 grains of nitrogen, and 4800 grains of carbon.

22. *What is the constant system of water service? What are its advantages, and what dangers may be apprehended from its adoption?*

22. By the constant system of water service is meant one in which the main pipes and the branches to the house are always full. Cisterns are not required, except for the water-closets; and, perhaps, one for storage of water should it ever be necessary to turn the water off from the main.

Its advantages are:—

(i.) It does away with the necessity of a cistern for storing drinking water, and consequently of all the ill effects of cisterns.

(ii.) The water can always be drawn pure from the main, and is in summer time cooler.

(iii.) With good fittings, the waste of water by the constant system is much less than by the intermittent.

(iv.) In case of fire the pipes are always full.

The constant system has one great drawback, viz., that the water has occasionally to be turned off from one to three days.

This of course should happen as little as possible. The danger of this lies in the fact, that the pans of water-closets are occasionally connected with the mains. Should the water be turned off, and the tap on the pipe leading to the water-closet be left open, suction takes place from the pan into the main ; and when the water is again turned on, the sewage matter is distributed to the occupiers of houses. Outbreaks of typhoid fever have been traced to this cause.

23. *What are the methods for examining the suspended matters in the air ?*

23. (i.) By Ponchet's aëroscope, which consists of a small glass funnel drawn out to a fine point, the end of which is just in contact with a drop of glycerine on a glass slide. The funnel and slide are contained in an air-tight chamber, through which the air is made to pass by an aspirator. Any suspended particles which fall down the funnel adhere to the glycerine, and can be examined microscopically.

(ii.) A thick glass tube is sterilised by being heated to a red heat, and then placed in a freezing mixture, and air drawn through it. The moisture in the air condenses on the inside of the tube, a drop of which can be put under the microscope.

(iii.) To examine for micro-organisms, the air should be drawn through tubes filled with sterilised cultivating media.

24. *What is meant by ventilation by propulsion? Describe one method of carrying it out.*

24. By ventilation by propulsion is meant the ventilation of a room or building by having the air propelled or forced into it. The usual method of doing this is to produce a current of air by the revolutions of a powerful fan. The air thus set in motion can be carried along conduits and distributed as desired.

25. *What are the requisites of a good house drain? How should it be ventilated?*

25. The requisites of a good house drain are :—

(i.) It should be made of glazed earthenware pipes, of from 4 to 6 inches in diameter.

(ii.) The pipes should be laid with a suitable fall towards the street sewer. They should be laid with their socket ends upwards, that is, the sockets should look in a direction opposite to that in which the sewage is flowing.

The pipes should be placed on a bed of concrete, so as to prevent sinking, and their joints should be firmly cemented all round, so as to avoid leakage. After the jointing has been done, it is important that the interior of the pipes be examined to see that no cement has been left opposite the joints, an oversight which may lead to obstruction in the pipes later on.

(iii.) A stoneware syphon trap should be placed between the house and street sewer, and from the house side of the trap a ventilating pipe should be carried up to the level of the pavement, and its mouth covered by a grating. If preferred, a manhole may take the place of this trap. From the highest point of the house-drain, that is, at the part most remote from the sewer, a vertical 4-inch pipe should be carried up full bore above the roof of the house.

26. *Describe the 'dry earth system' for the treatment of excretal refuse. What are its advantages and disadvantages?*

26. By the 'dry earth system' is meant the application of dried earth to the excreta in order to deodorise and absorb them. For the application of this system closets have been constructed, consisting of a receptacle for the excreta, provided with a hopper behind it for the storage and application of the earth. For each action of the bowel about $1\frac{1}{2}$ lb. of earth is required. Loamy earth is the best material, but sand and chalk are said to answer fairly well. After the treatment of sewage with earth, the compost or mixture may be dried and used again; or it may be dug into the earth as a manure. By this process the fæcal matter is literally absorbed by the earth, for every trace of excreta, and even paper, disappears. It was claimed that by this process the compost would form a valuable manure; but it has been found, that even after repeated applications a manure is obtained not richer than a good garden mould.

Its advantages are—that it is a good plan for small villages, schools, or temporary gatherings of people, where a water carriage system would be impossible. Even in this case, however, the closets require to be carefully supervised, or they are almost sure to become a nuisance.

Its disadvantages are:

(i.) The closets may degenerate into cesspools.

(ii.) The earth has to be collected, dried, and sifted.

(iii.) The compost has to be collected and carted away.

(iv.) In dry, hot weather there may be nuisance from the dust being blown about, and swarms of flies collecting.

(v.) The earth may fail.

(vi.) The apparatus for distributing the earth may get out of order.

27. *What methods should be adopted for preventing*—(i.) *Moisture ;* (ii.) *Air from the soil entering the house ; and why should these be excluded?*

27. Every house should have for its foundation a bed of concrete, which should be at least six inches thick, and extend on all sides beyond the limits of the house. By this means the ground air and damp are kept from rising through the floor of the basement. The ground air can also be kept out by raising the house on arches.

Should the soil on which the house is built be damp, it should be drained by agricultural pipes. Every house should also be furnished with a 'damp-proof' course—that is, the part below, and for a short distance above the ground, should be covered with waterproof material, such as concrete, asphalte, glazed tiles, sheet lead.

A damp house renders its occupiers liable to catarrhal affections, neuralgia, rheumatism, lung affections, &c.

Ground air is dangerous because it is often highly charged with carbonic oxide and acid gases; and may also give rise to malarial affections; and if the ground be contaminated by sewage, possibly to such diseases as typhoid fever, dysentery, and cholera.

28. *How would you disinfect a room, and the things in it after a case of scarlet fever?*

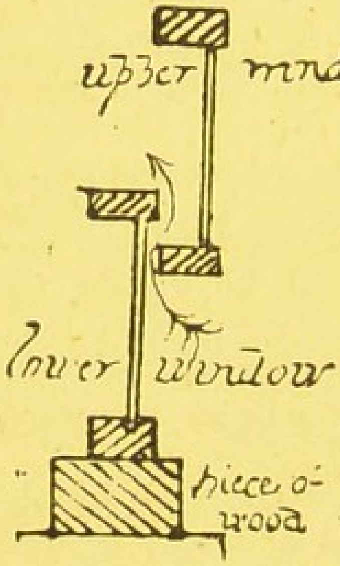
28. The wearing apparel, blankets, sheets, and other articles, should be dipped in some antiseptic, such as carbolic 1 in 20, perchloride of mercury 1 in 3000, or chloride of zinc; or may be baked. The windows should be shut, the chimney-plate closed down, and every outlet for air in the room blocked up. About ½-lb. of rock sulphur should be lighted and left to burn in an iron tray. The room should be kept closed for about 12 hours or more; after which the walls should be swept down, the ceiling whitewashed, floors scrubbed, and the room re-papered.

1886.

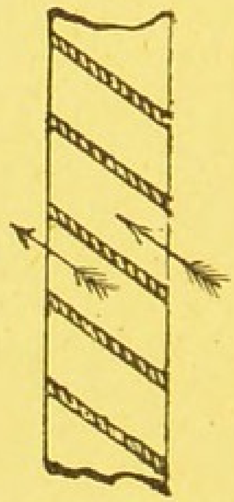
ELEMENTARY.

1. *What natural forces may be utilised in the ventilation of rooms? Give sketches of some simple appliances which may be used for this purpose?*

1. There are three natural forces of ventilation :

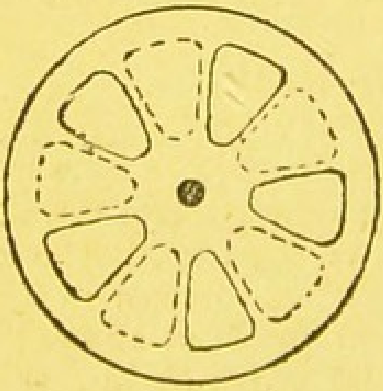


Hinche's Bird's Plan.

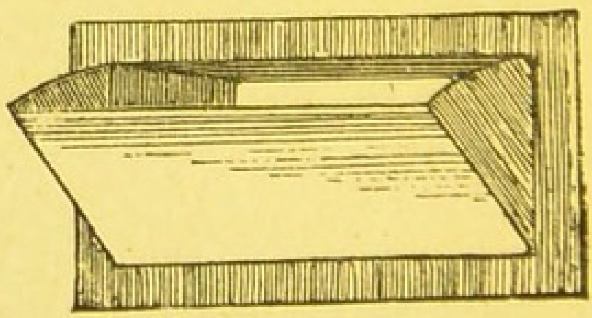


Louvre Ventilator.

(i.) The winds, which renew the air of a room by perflation, or by causing up-draughts up the chimney.



Cooper's Ventilator.



Sherringham Valve.

(ii.) Diffusion of gases, by which the composition of the air in a room becomes uniform.

(iii.) Movements of air, due to differences in density caused by changes of temperature owing to this hot air, ascends to the top of a room, while the cold, fresh air falls towards the floor.

2. *What refuse matters are produced in a kitchen? What should be done with them?*

2. The refuse matters obtained from the kitchen are :

(i.) Slopwater, obtained from the boiling of meat and vegetables, and from the washings of food, utensils, floors, &c. All slopwater should be sent down the sink, the outlet of which should be covered with a grating, and its wastepipe provided with a syphon-trap, fitted with a movable cap. The pipe should be carried through the wall, and discharge over a gully. In some cases the slop waste is carried into an automatic flush tank, which, when full, discharges itself into a gully. By this means the drains are kept flushed, and the possibility of a blockage from sand, grease, &c., is avoided.

(ii.) Dust and ashes. These should be deposited in the dustbin, which ought to be cleared out once a-week.

(iii.) Waste stuff from food. This should be burnt. It ought not to form part of the contents of the dustbin.

3. *What are proper sources of drinking-water for villages and for towns? How may a suspected water be rendered harmless for drinking?*

3. The sources of drinking-water for villages and towns are rain, springs, rivers, wells, and lakes. Rain water forms an excellent source of drinking-water for villages, as it can be obtained pure ; in towns it ought to be avoided, as it is often very dirty.

Springs afford waters which vary much according to the soils through which they have percolated.

Rivers in the neighbourhood of towns often become very polluted, owing to the practice of turning the sewage into them. Where this is avoided they offer good sources of water.

Lakes usually contain water that is very pure and soft, and is highly to be recommended for towns.

Wells : Surface wells are always a danger, whether in town or country. Deep or artesian wells, on the contrary, afford very good drinking-water.

The only sure way of completely sterilising water for drinking purposes is by repeated boilings. It is said the use of vegetable infusions renders an impure water much less harmful, an effect which is probably due to the tannin.

4. *Why is sleep necessary? Do children or adults require more sleep, and why?*

4. Sleep is necessary because it is the only state in which the body enjoys absolute and complete rest. Rest is as necessary to health as exercise, for it is during rest that tissue waste is repaired, and the growth of the body takes place. Children require more sleep than adults. During sleep two important things occur: (i.) combustion of tissue is less active; (ii.) assimilation is increased. In the child, tissue waste is more active than in the adult—hence the need for more sleep.

5. *What is the relative importance of the changes produced in the air by respiration?*

5. The most important change is the addition of a large quantity of foul organic matter, which is exceedingly poisonous to breathe; the increase of carbonic acid, although it means the addition of a noxious gas, is chiefly of import because it forms a good index to the amount of organic matter. The greater the carbonic acid the more the contamination with foul organic matter. The diminution of the oxygen only takes place to an amount which is practically insignificant in the air of a room.

6. *Compare the flesh of fish with butcher's meat as food. Mention some important differences in the flesh of various kinds of fish.*

6. The flesh of fish having a white colour contains less nitrogen than the red meat. It is also of looser texture, and contains very little fat. All these facts render fish flesh more digestible.

The flesh of salmon, mackerel, herring, &c., are exceptions, in that in all these species fat is plentifully intermixed with the muscle.

7. *Why do children require to be well clothed? What are the best materials for the clothes, and how should they be cleaned?*

7. [*For an answer to the first two parts of this question, see No.* 5 *of the Elementary*, 1884.]

Woollen clothing should be washed by being put into warm water, in which a lather has been formed with soap. It should be turned over and over, and then transferred to clean water. It should then be hung up to dry. Woollen materials should not be scrubbed, twisted, or wrung dry, as the hair gets damaged by these manipulations.

8. *Why is the drainage of the soil of a town necessary, and how should it be carried out? In what kinds of soil is drainage most essential?*

8. The drainage of soil of a town is necessary because it has been found that to dampness many cases of the following diseases are due. Phthisis, rheumatism, catarrhal affections, neuralgias, and, perhaps, typhoid (Pettenhofer's theory).

In order to drain the subsoil, two plans have been advocated.

(i.) To make the sewers permeable to moisture by perforations at intervals through the upper parts. This is a bad plan, because should the sewers at any time be running full they may overflow and contaminate the surrounding soil.

(ii.) By a separate system of drains made either of earthenware or brick. Whenever possible the separate system should always be adopted. Drainage is most essential in marshy and and alluvial soils, made soils, clay, and in gravel, chalk, or sand if underlaid by clay.

9. *State the composition of* (i.) *an 'average' diet;* (ii.) *a subsistence diet; and give an example of the former with ordinary foods.*

9.

	Average diet in ounces.		Subsistence diet in ounces.
Nitrogenous	4½	Nitrogenous	2
Carbohydrates	14	Carbohydrates	11
Fats	3	Fats	½
Salts	1	Salts	½

For an average diet with ordinary food, the following may be taken as an example:—

Meat, 9 ounces; bread, 28½ ounces; butter, 1½ ounces.

10. *What food substances especially aid the action of the 'intestine?' What is the importance of regular action?*

10. The following substances aid the action of the intestine :

(i.) Water.

(ii.) Salts, which causes an exudation of serum into the bowel.

(iii.) Fats, which act as lubricants and also stimulate peristaltic action.

(iv.) Vegetable foods, which by means of the cellulose and other indigestible materials which they contain act as irritants to the bowel. A neglect of the regular action of the bowel may cause an accumulation of fæcal matter in the intestine, and obstinate constipation, or constipation alternating with diarrhœa and ulceration of the bowel. If fæcal matter is allowed to lodge for long in the bowel, absorption of products of putrefaction occurs which cause an earthy complexion and a condition of ill-health known as 'copræmia.'

11. *What are the physiological effects of alcohol and of alcoholic drinks used in moderation and in excess?*

11. The physiological effects of alcohol are: Stimulation of secretion of the salivary and gastric juices; increased flow of blood to the liver; the heart's action is quickened and strengthened; the cutaneous capillaries dilate, and profuse sweating results; the quantity of the urine is augmented. On the brain alcohol acts first as a stimulant, but this effect soon gives place to depression. Muscular action is weakened. The temperature, except in very large doses, is unaltered. If alcohol produces any effect on the temperature it lowers it.

A poisonous dose of alcohol causes coma, general muscular relaxation, and a fall in the temperature.

The habitual use of alcohol in excess causes an overgrowth of fibrous tissue in every organ of the body and premature decay.

Even in physiological doses alcohol cannot be considered a food in the strict sense, for it is neither a part of the tissues, nor does it supply the body with heat or muscular energy.

12. *A person has been run over by a cab, his arm is apparently broken, and is bleeding fast. What would you do?*

12. The treatment in this case would depend on whether the

patient were bleeding externally, or whether the fractured ends of the bone had cut across an artery which was ploughing up the tissues subcutaneously with blood.

In the former case, the first thing to be done is to arrest the hæmorrhage. If this be merely capillary, or from a small vessel, the limb should be raised, and the wound bathed with hot water at a temperature of 105° Fahr. containing some antiseptic. If the artery be of moderate size it should be caught in a pair of artery forceps, and either twisted or tied with a ligature of catgut. Veins may also require ligation in the same way.

The wound should then be very carefully syringed with antiseptic solution, and all dirt and foreign matter removed. If the wound be clean cut, it should be closed; if it be contused, with ragged edges, it had better be left unstitched. The limb should then be put up in an appropriate splint with an antiseptic dressing.

In the second case, the treatment would depend on the extent of the hæmorrhage and the state of the patient. Should the hæmorrhage not be abundant, the arm should be placed in a splint and treated as an ordinary fracture. Should the hæmorrhage be increasing, and the patient getting faint from loss of blood, ligature of the artery above the seat of fracture may be required. This last operation should only be performed by a competent surgeon.

1886.

ADVANCED.

21. *Compare and contrast the various cereal grains as to their composition and economic uses.*

21. COMPOSITION OF CEREAL GRAINS IN 100 PARTS.

	Water.	Albuminalis.	Fats.	Starch.	Salts.
Wheat	15	11–18	2	70	1·7
Barley	15	12	2	70	1·7
Maize	13·5	10	6·5	64	1·4
Oats	15	12·6	5·6	63	3
Rice	10	5	·8	83	·5
Millet	12	11·13	3·6	67	2·3

From the table it will be seen that wheat and barley approximate closely in composition. Some of the finer varieties of Sicilian wheat, however, may contain as much as 18 per cent of nitrogenous matter. Wheat differs from barley in containing more gluten, from which peculiarity it lends itself more easily to the making of bread.

Both wheat and barley are comparatively poor in salts. Maize and oatmeal, while containing a good amount of albumenates, are rich in fats and salts, and are therefore highly nutritious foods. Rice is poor in nitrogenous matter, fats, and salts, but rich in starch. It is, therefore, customary amongst rice-eating people to make up for this deficiency by adding meat, fat, butter, cheese, &c., to the rice.

22. *Contrast the physiological effects of breathing rare and dense air, and of living at different altitudes.*

22. While breathing rarified air, the chief sensation experienced is one of heaviness, due to the difficulty of getting oxygen. The pulse and respiration are quickened; there is

determination of blood to the surface, and hence a liability to hæmorrhages ; the action of the skin is increased, while internal secretions are diminished. With great rarefaction of the air, the voice becomes weak ; there may be disgust for food and vomiting.

The effect of an increased density of the air is to supply more oxygen at each inspiration. It therefore causes a slowing of the respiration and pulse ; determination of blood to the interior of the body with increase of internal secretions, while the action of the skin is diminished. If the increase in density of the air be extreme, the skin becomes pale ; giddiness, headache, and even delirium may supervene ; there is pain in the ears owing to difference in pressure on the tympanic membrane, and the voice becomes resounding and metallic-like.

23. *Under what circumstances would carbonic oxide be found in the air of a room? What effects does it produce?*

23. Carbonic oxide may be found in the air of a room from :

(i.) The use of coke or charcoal fires, without a proper flue to carry away the products of combustion.

(ii.) From an escape of coal gas from a leaky gas-pipe.

(iii.) From a house being too near to a limekiln or brickfield, so that the carbonic oxide which is largely produced, enters the rooms, should the windows be left open which look on to the field.

Carbonic oxide is a virulent poison, because it turns out the oxygen from oxyhæmoglobin, and enters into a very stable combination with that body. It produces headache, giddiness, great prostration and faintness, and drowsiness. In some cases, vomiting and oppressive feeling on the chest also result, and, finally, death.

24. *What are the materials used for filtering water on the small scale? How do they act? What points should be attended to in the construction of a domestic filter?*

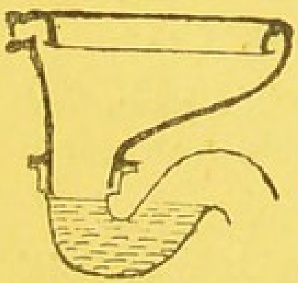
24. The chief materials used for filtering on the small scale are : charcoal, carferal, silicated carbon, scrap iron and spongy iron, and, sometimes, sponge.

Filters act in two ways : (i.) Mechanically, so that the matter in suspension in the water is deposited on the filtering medium as it runs through it; (ii.) chemically, chiefly by oxidation, or, as in spongy iron, by deoxidation.

A good filter should possess the following qualifications: (i.) It should admit of being taken to pieces, so that every part of the filter can be cleaned, and the filtering material, if necessary, be renewed or renovated; (ii.) it should be a good purifier of the water; (iii.) the filtering material should be fairly lasting; (iv.) it should yield nothing to the water in the shape of products of putrefaction, micro-organisms, or metallic impurities.

25. *Sketch and describe a good form of hopper water-closet. How should it be supplied with water?*

25. The hopper closet consists of a hopper or basin of glazed stoneware, the back of which is nearly vertical, while the front slopes gradually downwards to the outlet where there is a syphon trap, which should be kept constantly full of water. The basin and trap should be cast in one piece. Water should be supplied from a water-waste prevention cistern capable of holding from two to four gallons, and should be delivered into the hopper by means of a flushing rim, and not by a spreader. This form of closet is known as the 'short hopper,' and is much to be preferred to the old 'long hopper' variety.



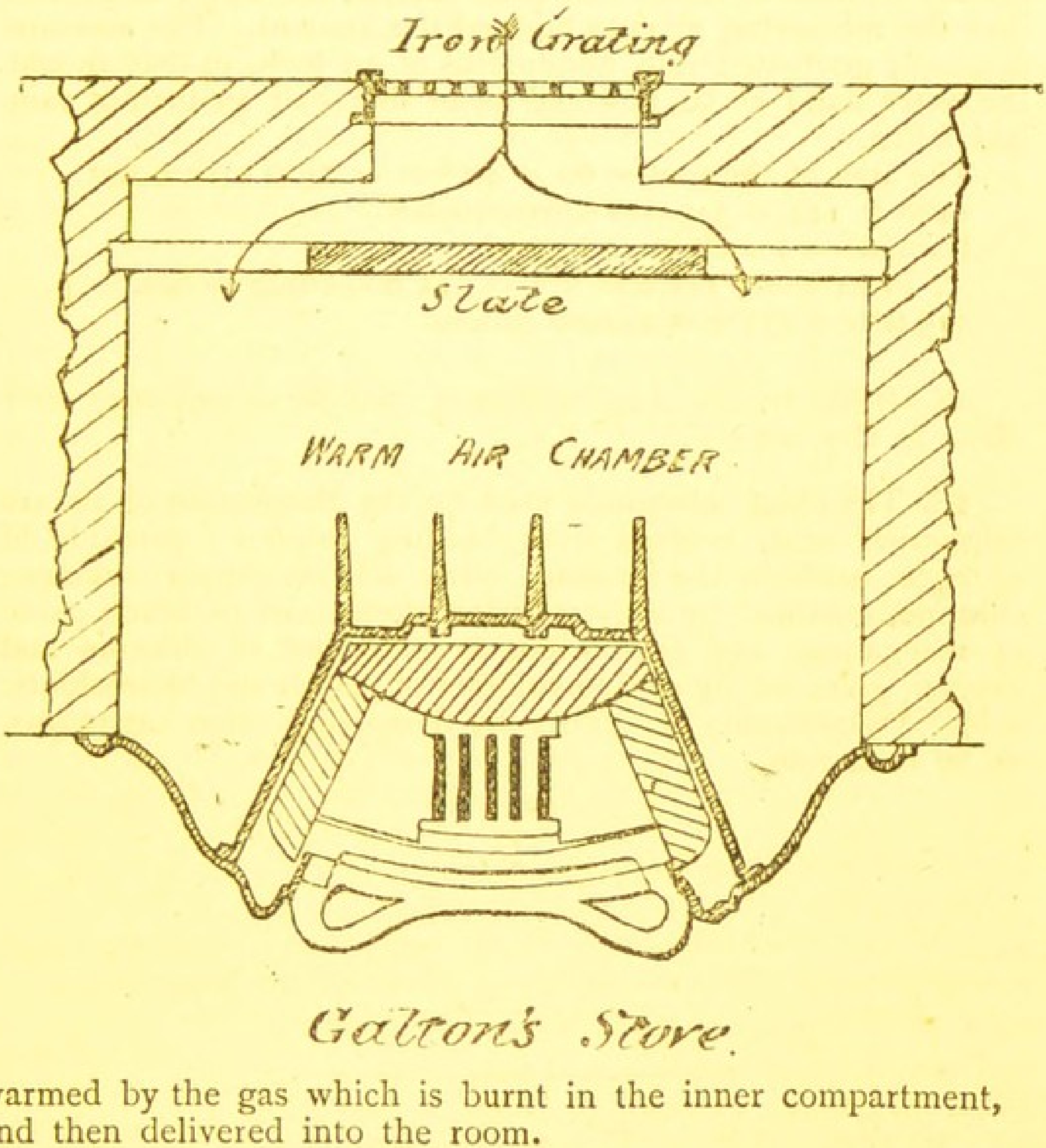
Short Hopper Closet.

26. *Describe some stoves with arrangements for the admission of warmed fresh air into rooms. Give a sketch of one of them.*

26. The best form of stove for the admission of pure warmed air into a room is Galton's. In this stove, behind the fireplace, is an air chamber, in which are cast several iron flanges, which project backwards, and serve to increase the heating effect of the chamber. The latter communicates with the external air. Air having been warmed in the chamber is admitted into the room by two louvred openings, placed one on each side of the mantelpiece.

Boyle's stove is based on the same principle as Galton's.

Of gas stoves for admitting warmed air into a room, George's Calonjan stove is one of the best. It consists of two compartments, an inner and an outer. In the outer is placed a coiled tube through which the air is conducted from the exterior, and



Galton's Stove.

warmed by the gas which is burnt in the inner compartment, and then delivered into the room.

27. *Describe the rain-gauge, and the method of graduating its measuring glass. If one inch of rain falls in twenty-four hours, how many gallons of water can be collected during that time from a roof sixty feet by forty feet?*

27. The rain-gauge consists of a metal cylinder, into the top of which is fitted a funnel, also metallic, having its upper rim

carefully turned. The end of the funnel is allowed to hang into a glass vessel or jug to catch the rain. After the rainfall for a certain number of hours has been caught, the water is poured into the measuring glass to find out the amount. The measure is usually graduated into hundredths of an inch, so that should the water stand at 50, it would mean that half an inch of rain had fallen.

The area of the roof = 60 × 40 feet = 2400 square feet.

2400 × 144 = 345,600 square inches.

Rainfall = 1 inch in 24 hours.

∴ in 24 hours 345,600 × 1 = 345,600 cubic inches.

345,600 ÷ 277·2 = 1210·6 gallons.

28. *What are the chief substances used for disinfecting air? How do they act?*

28. The chief substances used for the disinfection of air are sulphurous acid, evolved from burning sulphur; peroxide of nitrogen, made by the action of nitric acid on copper turnings; chlorine, obtained by adding hydrochloric acid to black oxide of manganese, and euchlorine, a compound of chlorine and oxygen, given off by mixing chlorate of potash and hydrochloric acid. Disinfectants act either by destroying micro-organisms, or by oxidation.

HINTS AND NOTES.

In the foregoing pages are contained the answers to the questions on Hygiene, set at the Elementary and Advanced Examinations of the Science and Art Department of South Kensington. As these questions only extend over a period of three years, much that is important has necessarily not been touched upon. It is with a view of making up these deficiencies in the range of the answers that I have contributed the following notes on the most important four subjects of the syllabus, viz., food, water, air, and refuse matters.

In preparing for examination, students should on no account be tempted to make these answers and notes do duty as a text-book, but should acquire their knowledge from one of the standand works on Hygiene. The objects which the publishers have had in view in bringing out these books have been to place in the hands of students a set of model answers, and to give them a mass of information in a condensed form, and in a shape suitable for quickly refreshing their memories after having carefully read a text-book upon the subject.

FOOD.

Classification of Foods.

I. Inorganic	Water.	
	Salts ...	Soda.
		Potash.
		Lime.
		Iron.
		Magnesia.
II. Organic	Non-nitrogenous	Fats and oils.
		Carbohydrates.
		Miscellaneous, such as vegetable acids, alcohol, &c.
	Nitrogenous ...	Albuminoids.
		Gelatinoids.
		Vegetable alkaloids.

Uses of Food.

The most important food stuffs are the albuminoids and gelatinoids, fats, and carbohydrates.

The albuminoids go to build up the organic framework of the body, in which oxidation and transformations of energy take place, but to which they do not contribute in the same proportion as the other two important food stuffs.

During exercise the excretion of carbonic acid and water only is increased; while the amount of urea eliminated by the urine remains fairly constant, showing that for the production of heat and mechanical motion, nitrogenous substances do not take so large a share as fats and carbohydrates. Part of the albuminoids that are digested, however, go to form fat, and may thus indirectly contribute to the production of energy. That fat is produced from albuminoids has been proved by the experiments of Lawes and Gilbert on pigs, who showed that the fat stored up in fattened pigs must have been partially derived from nitrogenous food.

The part that gelatinoids play in the economy has already been considered. Fats are of use to the body, partly to supply tissue waste and partly to generate heat. Carbohydrates do not enter into the formation of any tissue, but are converted into sugar, and then stored up in the liver as a peculiar form of starch called glycogen.

Fats and carbohydrates become sources of energy to the body by undergoing oxidation, during which process an evolution of heat takes place. In fats, carbon and hydrogen are available for oxidation; but in carbohydrates, only the carbon can be used, because hydrogen and oxygen occur combined in them in the same proportion as in water. Although carbohydrates and fats subserve the same purposes as foods, they cannot replace each other in a diet.

Every diet must, of course, contain salts and water in addition to albuminoids, fats, and carbohydrates. The loss of iron produces diminution of red colouring matter or hæmoglobin of the blood, and the disease called anæmia; the abstraction of phosphate of lime, and also of magnesia, is followed by softening of the bones. Such organic salts as citrates, tartrates, malates and acetates give alkalinity to the body, and their absence from food causes the state of malnutrition named scurvy. They are contained chiefly in green vegetables and fruits; hence the advantage of having a proper supply of these in a diet, despite the large amount of indigestible matter which they frequently contain.

Characters of good meat.—Meat should be of a pinkish-red colour, marbled with fat, firm and elastic. Purple meat is said to indicate that the animal has not been slaughtered, but has died from some other cause; pale meat shows the flesh of a young animal, or one that has suffered from a wasting disease. Meat should have a pleasant smell, and should offer an equal resistance through its whole thickness to the blade of a knife when plunged into it. It should exhibit no evidence of parasitic disease or abscesses, nor should the meat have a medicinal smell. The flesh of young animals contains more water, and is therefore less nutritious than that of the adult.

Characters of Good Milk.—Specific gravity 1030; alkaline reaction; on standing the milk in a tube for 10 to 12 hours the cream should collect at the top and form a layer not less than 10 per cent by volume. The total solids should be at least 12½ per cent; and should consist of fat, 3·2 per cent; casein, 4 per cent; sugar, 4·5 per cent; and salts, ·9 per cent.

Eggs consist of 70 parts of water and 30 per cent of solids. The white contains egg albumen; the yolk is composed of fat 31 per cent, 16 per cent albumen, and the rest of water.

Eggs are deficient in heat-producing agents and mineral matter.

Butter should consist of 90 per cent of fat, and not more than 3 per cent of curd (casein). Butter is adulterated with foreign fat and water.

The leguminous plants contain a large amount of nitrogenous matter, named vegetable casein, or legumen, which varies in amount from 24 to 29 per cent; and they are also rich in salts, especially phosphates. They are very nutritious but indigestible, unless subjected to prolonged boiling.

The amounts of energy obtainable from some of the principal foods expressed in foot-tons per ounce is the following:—Uncooked meat, 48 to 96 f.t.; cooked meat, 106 f.t.; white fish, 44 f.t.; bread, 87 f.t.; wheat flour, 124 f.t.; oatmeal, 130 f.t.; potato, 33 f.t.; cabbage, 13 f.t.; butter, 345 f.t.; milk, 27 ft.; sugar, 126 f.t.; ale, 30 f.t.

Only about $\frac{1}{6}$ of the total energy of ingested food is available as force.

The diet requisite for a man in very laborious work is:

Albuminates,	$6\frac{1}{2}$	ounces, water free.
Fat,	$3\frac{1}{2}$ to $4\frac{1}{2}$	,, ,,
Carbohydrates,	16 to 18	,, ,,
Salts,	1·2 to 1·5	,, ,,

Calculation of Diet.—Suppose we wish to find out how much meat, bread, and butter a man should be allowed for an average diet in the 24 hours.

We have seen that an average diet should be $4\frac{1}{2}$ ounces of albuminates, 3 ounces of fat, and 14·25 of carbohydrates.

Now, the percentage composition of meat, bread, and butter is as follows :

	Alb.	Fat.	Carbohyd.
Meat	25	15	0
Bread	5	1·5	50
Butter	0	90	0

Let x = ounces of meat.
y = ounces of bread.
z = ounces of fat.

Then
$$\frac{25}{100}x + \frac{5y}{100} = 4{\cdot}5 \qquad \text{(i.)}$$
$$\frac{15x}{100} + \frac{1{\cdot}5y}{100} + \frac{90z}{100} = 3 \qquad \text{(ii.)}$$
$$\frac{50y}{100} = 14{\cdot}25 \qquad \text{(iii.)}$$

$$\therefore\ 25x + 5y = 450.$$
$$15x + 15y + 90z = 300.$$
$$50y = 1425.$$

From which x = 12·3 (meat).
y = 28·5 (bread).
z = ·8 (butter).

Beverages.—*Tea, coffee, and cocoa.*—Each of these substances contains an alkaloid, viz., theine, caffeine, and theobromine, respectively. In small amounts these alkaloids are nervine stimulants, and remove the sense of fatigue. They also act as diuretics and diaphoretics. In large doses they are poisons. These alkaloids are all soluble in boiling water, but not in water at a lower temperature.

The drinks made from these plants are usually taken hot. In cold climates they produce a sensation of warmth ; while in warm temperatures, by dilating the cutaneous capillaries and causing perspiration, they favour evaporation from the surface, and thus produce a cooling effect.

Tea is said to have a purifying action on water, owing to the precipitation of organic matter by the tannin.

Tea may be adulterated by admixture with other leaves, such as oak, willow, beech, &c., by colouring old leaves with indigo or prussian blue, or by rubbing the leaves up with manganese, lead, or dirt. The most frequent fraud practised on tea is the sale of exhausted leaves.

Coffee may be adulterated with chicory, date seeds, beans, &c.

Alcohol.—It was found by Dr. Parkes that the greatest amount of pure alcohol which a man could get rid of in his body varied from an ounce to an ounce and a half in the 24 hours. If larger quantities than this were administered the alcohol appeared unchanged in the urine.

WATER.

WATERS are classified by the Rivers Pollution Commissioners into the following varieties:—

(i.) Wholesome	Spring water Deep well water	Very palatable.
	Upland surface water	Moderately palatable.
(ii.) Suspicious	Stored rain water	Moderately palatable.
	Surface water from cultivated land	Palatable.
(iii.) Dangerous	River water contaminated by sewage Shallow well water	Palatable.

The palatableness of water is no guide to its purity. An agreeable taste is usually due to the dissolved carbonic acid. Waters containing large amounts of nitrites, nitrates, and phosphates, may be bright, sparkling, and nice tasted, although their composition shows them to have been subjected to sewage contamination.

Water may be highly impregnated with salts and the contamination not be detectable by the taste. Thus each gallon of water may contain 75 grains of salt, or 60 grains of carbonate of soda, or 50 grains of chloride of magnesium, and the flavour of the water be quite unchanged. Iron forms an exception to this statement, for as little as $\frac{1}{5}$ grain to the gallon is sufficient to impart a chalybeate taste to the water.

Nitrites and ammonia are evidences of recent sewage contamination, while nitrates, phosphates, and in some cases chlorides, show that the water at some previous time has had sewage mixed with it.

Organic matter in water may be either vegetable or animal. All natural waters contain vegetable matter in varying proportions. As a rule, vegetable matter is harmless, as, for instance, that derived from peaty soils, where the water may contain so much vegetable impurity that it is stained brown.

Water containing acrid plants, or derived from marshy soil, is always harmful. Animal organic matter may be either living or dead. Dead animal matter may have found its way into water either by the bodies of animals having fallen into it, or from sewage contamination. Sewage may enter water either from the faulty construction of water-closets and cisterns, or by leaking and overflowing cesspools contaminating wells, or by being deliberately turned into streams and rivers. Sewage matter may sometimes be revealed by microscopic examination, when the water may be found to contain muscle fibres, epithelial scales, starch cells, debris of food, &c.

As to the influence of living organisms in the water we are yet in the dark. Of course, bacteria of specific diseases will, if swallowed in water, generate the special diseases of which they are the cause, but of other microscopic organisms we cannot speak positively.

Good drinking water is either of a bluish or greyish tint. Water containing vegetable matter is greenish, yellow, or if it contain peat, brown. Iron imparts a yellow colour to water.

The most suspicious colour for water to have is yellow.

The metals which may find their way into water are iron, copper, manganese, arsenic, zinc, and lead.

Iron and manganese are harmless.

Iron gives water an astringent flavour, while manganese is tasteless.

Copper may contaminate springs near copper mines, or may be dissolved in water from cooking utensils.

Arsenic usually gets into streams by the refuse of dyeing works being turned into them.

The way in which zinc finds its way into water has already been explained in treating of galvanised iron cisterns.

Lead.—The amount of this metal in water which is sufficient to produce poisonous symptoms has been much disputed. Probably Professor Wanklyn's statement that water holding more than $\frac{1}{10}$ grain to the gallon should be rejected is a correct one. The waters which exercise the greatest solvent action on lead are those charged with large quantities of oxygen, vegetable and organic matter, nitrites and nitrates, and chlorides. Waters containing carbonates, sulphates, and phosphates, do not dissolve lead, but actually prevent its solution by forming a crust upon the surface of the metal, and thus preventing the further action of the water.

Water may be contaminated at one of four points:

(i.) At its source, owing to the surface which it has washed, or the soil through which it has percolated.

(ii.) During its transit from its origin to the reservoir, especially by sewage and manufacturing impurities.

(iii.) In its storage in cisterns and reservoirs.

(iv.) In its distribution, either from the material of which the pipes are made, or from coal or sewer gas being sucked into the water pipes.

Sources of water:

(i.) Rain water in some cases forms the only supply, as in the country districts. It may be collected either in gathering grounds, such as sands and uplands away from houses, or from roof tops. The former is the plan practised in Holland, the latter that usually adopted in this country. The latter plan is open to the objection that the water becomes contaminated by soot, leaves, dirt, droppings of birds, &c. These objections are overcome by the use of Roberts' percolator, the principle of which is to reject the first portions of the rain water by allowing them to run to waste. The instrument is balanced on a pivot, and is divided into two compartments. When collection is first commenced the rain water flows mainly through one of the compartments, and then runs to waste, but at the same time a little of the water gets into the second compartment. As the flow continues the latter gradually fills, and when the water has reached a certain height the instrument tips over, after which all the liquid that runs through is conducted to a storage reservoir.

Rain water should not be stored in lead or galvanised iron cisterns, for being highly oxygenated, the metals are quickly dissolved. Iron cisterns soon rust, and hence should be coated over with some protective. Stone rendered with cement or slate forms the best material for cisterns for storing rain water. In country places rain water is usually stored in butts. These, if kept clean and properly covered, form good receptacles.

(ii.) *Springs.*—Of the water which falls on the earth as rain a part evaporates, some runs off into the nearest water-course, and the rest sinks into the earth. The water which has sunk into the earth reappears at some other point as a spring.

Spring water varies much in composition. At times it may be highly charged with salts and be quite undrinkable for ordinary purposes, but only fit for medicine; in many cases, however, springs furnish some of the purest waters, which contain rather more salts than upland surface water, but very little organic matter, and being well aerated, are very palatable.

(iii.) Rivers form good sources of water supply, unless contaminated by sewage and manufacturing refuse. Water from rivers may either be stored up in reservoirs, or the reservoir be formed in the stream itself by damming it up.

(iv.) Upland surface water from uncultivated land is a wholesome source of supply. The water contains very little solid or organic matter.

(v.) Water from cultivated land, owing to the manure which is applied to the soil, is always suspicious.

(vi.) Lakes yield very good and soft water. An excellent example of the purity of this water is that of Lake Katrine, which supplies the city of Glasgow.

(vii.) Wells are of three kinds, viz., shallow, deep, and artesian.

A shallow well is sometimes defined as one that is less than fifty feet deep, and a deep well one that extends down for a greater depth than this. A better definition would be to say that a shallow well is one that is sunk into the superficial porous soil and taps the water lying on an impermeable stratum below, while a deep well taps the water contained between two impermeable strata. According to this definition a deep well may be actually shallower than a shallow well.

An artesian well is one which is sunk into a water bearing stratum, the highest point of which is usually at a considerable distance from, and at a much higher level than, the surface of the water in the well; so that on this stratum being tapped the water tends to rise up in the well to the level of its highest point. The water of an artesian well is warm, and contains less oxygen and more ammonia than ordinary spring water. It may also be highly impregnated with salt.

TABLE OF MINERAL MATTERS IN WATER.

	Total Solids.	N as nitrates. Parts per 100,000.	Chlorine.
Rain	3	·003	·2
Upland surface	10	·01	1
Deep well	44	·5	5
Spring	28	·4	2·5
Sewage	72	0	10–11
Sea water	3900	·033	1975·6

The inner surface of a well should be steined, that is, provided with a coating which will effectually keep out the impurities in the soil above the level of the water in the well. The steining should consist either of bricks set in good cement, or of iron covered with some protective.

Wells should have their tops covered, and raised above the level of the soil to prevent anything falling in, and to keep out surface washings ; the water should be withdrawn by pumps. Open or draw wells are objectionable.

Quantity of Water.—The quantity of water supplied to the population per head varies greatly in different towns. In Norwich it is only 14½ gallons ; in London 25 to 30 gallons ; while in Glasgow 50 gallons are supplied daily.

The use of the water is usually apportioned out in the following way.

	Gallons.
Domestic purposes	9
Weekly baths	5
Closets	5
Washing clothes	3
Waste	3
	25
Town purposes	5
Trades	5
	35

Purification of Water.—May be accomplished either without or with filtration.

The chief methods in use without filtration are :

(i.) To expose water in finely divided streams to the air.

(ii.) By boiling water adult micro-organisms are destroyed, but the spores, being able to resist very high temperatures, survive. The only way to completely sterilise water is by repeated boilings, by which the sphores are at length completely destroyed, because on commencing to grow they soften, and are thus more easily killed.

(iii.) By the addition of alum to the water lime is precipitated as sulphate, which with the hydrate of alumina carries down suspended matter.

(iv.) By Clarke's process, lime water being added to the water, the lime combines with the free carbonic acid in the water, and this additional quantity of calcic carbonate has the effect of carrying down the chalk which was previously in solution, and with it some of the organic matter. An objection to this process is that the precipitate is an exceedingly fine one, and takes many hours to settle. A modification of this plan is to add the precipitant, and then strain the precipitate through asbestos cloth.

(v.) Other substances, such as permanganate of potash, perchloride of iron, nux vomica, iron wire, &c., are used for the purification of water.

Of these permanganate of potash is of use in ridding water of disagreeable smell, but its use is objectionable on account of the unpleasant taste it imparts to water.

Perchloride of iron is said to be effective in removing clay and suspended organic matter from water.

With Filtration.—This may be required on either a large or small scale. On the large scale water companies usually employ a layer of sand and gravel as the filtering medium. They are usually arranged as beds from three to five feet in thickness, the upper layers of which are of fine sand, while the lower part is of gravel, which gradually increases in coarseness to the bottom, the lowest layer being composed of stones as big as hen's eggs. The layer of water on the sand never exceeds two feet in depth, while some companies only allow one foot of water. The rate of filtration varies from 70 to 140 gallons per square foot in the twenty-four hours. Sand acts as a purifying agent on water, partly mechanically and partly chemically, through the influence of the oxygen which it holds in its interstices. To be purified water must run through sand in a downward direction ; forcing the water upwards is of no use.

Instead of sand and gravel, some companies employ sand and magnetic carbide of iron ; and others spongy iron.

The substances used for domestic filters are sponge, animal and vegetable charcoal, carferal, silicated carbon, and magnetic oxide of iron. Of these silicated carbon, carferal, magnetic oxide of iron, and animal charcoal are the best.

Vegetable charcoal is not a very efficient purifier, while sponge is an exceedingly bad one, and very soon becomes foul. Animal charcoal is a powerful purifier of water, but its use is open to the following serious objections :

(i.) Its purifying action ceases after a little time.

(ii.) After use for a little while it yields up foul organic matter to water if kept in contact with it.

(iii.) Water filtered through animal charcoal and stored, very soon swarms with micro-organisms.

(iv.) It allows organic matter to pass through it unchanged.

AIR.

Respiratory Impurities.—The experiments of the late Dr. de Chaumont alluded to in Answer 1, 1884, of the Elementary Examination, by which he was enabled to determine the limit of carbonic acid impurity in a room, were the following:—The experiments were made in barracks on soldiers. Each room was entered directly from the open air, and the sensations experienced were noted at once, and after being recorded, a sample of the air of the room was collected for analysis. At the same time the temperatures of the dry and wet bulb thermometers and the humidity of the air were noted.

Dr. de Chaumont divided his samples of air into five classes, viz. :

(i.) Not close contained CO^2 ·2 per 1000 cubic feet above that in outer air.

(ii.) Rather close contained CO^2 ·4 per 1000 cubic feet above outer air.

(iii.) Close contained CO^2 ·6 per 1000 cubic feet above outer air.

(iv.) Very close } contained CO^2 ·85 per 1000 cubic feet
(v.) Offensive } above outer air.

He also found:

(i.) That the temperature of the dry bulb thermometer ought to read between 63° Fahr. and 65° Fahr., and ought not to fall below 60° Fahr.

(ii.) That the wet bulb thermometer should read between 58° Fahr. and 61° Fahr., and that the difference between the dry and wet bulb thermometers should not be less than 4°, and more than 5°.

(iii.) The humidity ought to range between 70 and 75 per cent.

Dr. Angus Smith has designed a household test for carbonic acid impurity in air. His test consists in using bottles of the following sizes, which are filled with the air of the room to be examined. Into the bottles half an ounce of lime water is poured and shaken up. If the lime water become turbid it indicates an amount of carbonic acid in the room as follows:—

Ounces (bottles).	CO^2 in air per 100 cubic feet.
20·6	·03
15·6	·04
12·5	·05
10·5	·06
9·1	·07
8·0	·08
7·2	·09
6·5	·1
6·0	·11
5·5	·12

Hence, according to this test, if a 10½-ounce bottle have half an ounce of lime water poured into it after being filled with some of the air of a room, and the lime water remain clear after being shaken up, it shows that the air of a room contains less than ·06 carbonic acid per 100 cubic feet, and is therefore in a fit state to be breathed.

The causes which produce deterioration of the air are:

(i.) Respiration.

(ii.) Combustion.

(iii.) Gases and suspended matters given off by trades and manufactures.

(iv.) Sewage emanations.

Of these, respiration is by far the most important, and its effects on the composition of pure air have already been fully explained in several of the preceding answers.

Combustion produces by the side of respiration a comparatively slight vitiation of the air. Its chief products are carbonic oxide, carbonic acid, water, and smoke.

The chief impurities from manufactures which vitiate the air are:

(i.) Vitreous phosphorus from the manufacture of matches was once an important one, but it is now no longer used. It produced caries of the lower jaw amongst the workpeople.

(ii.) Bisulphide of carbon from the manufacture of india-rubber. It is a heavy, volatile liquid, and hence tends to settle towards the lower parts of a room. Children are, therefore, the chief sufferers from the inhalation of its vapour. It causes headache, diarrhœa, vomiting, and even paralysis.

(iii.) Chlorine gets into the atmosphere of places where bleaching powder is manufactured. It is a respiratory irritant, and causes cough, spitting of blood, and suffocation.

(iv.) Hydrochloric acid gas is formed as a residue in the manufacture of carbonate of soda from salt. It used to be allowed to escape into the air, and, as a consequence, caused destruction of the surrounding vegetation. By the Alkali Works Regulation Act, 95 per cent of this gas must be condensed, before being allowed to escape into the air.

(v. Sulphurous acid is given off from the smelting of copper sulphide, from the use of sulphites in the washing of wool, and during the combustion of coal gas.

(vi.) Hydrogen sulphide is given off into air from decomposing animal matters, foul sewers and cesspools, and also from many mineral springs and volcanic soils.

(vii.) Arsenic has already been discussed.

(viii.) Zinc contaminates the air of brass founderies. It gets into the air in the form of oxide of zinc, and gives rise to brass-founders' ague.

(ix.) Mercury, from the silvering of mirrors.

(x.) Dusts from coal and metal mines, from the manufacture of pottery, china, glass, steel, Portland cement, pearl buttons, cotton, silk, wool, and linen.

The chief sources from which foul organic vapours find their way into the air are: From the manufacture of artificial manure, bone boiling, soap boiling and rendering of fat, gut spinning, from sewers and cesspools, and from brick and cement making.

It should be mentioned in connexion with this subject that Parent-Duchatel who investigated the effect of sewer air upon the health of the men employed in sewers, failed to trace any evil effects in the workpeople beyond a form of ophthalmia.

REMOVAL OF WASTE AND REFUSE MATTERS.

REMOVAL of excreta from the house may be accomplished either according to the dry or wet system, the former being known as the conservancy, and the latter as the water carriage system.

Conservancy.—The earliest form of this plan was to construct cesspools, which were merely deep pits dug out of the earth into which solid and liquid refuse were thrown, the former being allowed to disintegrate, and the latter to soak away into the surrounding soil. In the midden the excreta were mixed with ashes and house refuse of all kinds. The first improvement in the midden and cesspool was to make them water-tight by lining them with bricks set in cement, and coated internally with a lining of cement. They were either provided with an overflow pipe or drain pipe to carry away the liquid into the nearest stream or ditch.

In many Continental and even English towns the cesspools are still in use. In Paris, each house is provided with a cess-pool or 'fosse permanente,' which periodically has its contents pumped out.

By degrees the midden became gradually reduced in size. It was raised above the level of the ground, and, finally, was converted into a privy, the midden being the space between the seat and floor. If constructed at the present time, the model by-laws of the Local Government Board provide that the midden shall not have a capacity exceeding eight cubic feet.

The pail and tub system is the outcome of the old midden. The receptacle is a movable pail or tub, which, when full, is covered with a closely fitting lid. The pail or tub is placed beneath the seat of the closet. Each receptacle has a capacity of two cubic feet, and, therefore, requires frequent changing. In some towns, the whole of the refuse of the houses, solid and liquid, is received into these tubs; but in those places where it is desired to secure a fairly good manure, the contents are kept as dry as possible, and only the fæces, urine, and fine ashes are collected.

In Goux' system, pails are used which are lined internally with some absorbent material like shoddy, tan, or wood shavings, and the contents are sprinkled over with some deodorant, such as charcoal or gypsum.

The Dry Earth System.—The treatment of excreta by dry earth originated with the late Rev. H. Moule, who in proposing its application to human refuse, stated that by this process the organic substances in the excrement underwent a change into the state in which organic matter naturally exists in the soil, in such a way that it became available for supporting plant-life without undergoing reduction into simple salts and gases. That excretal matter does undergo a very decided change by the addition of earth is certain; for after some time no trace of fæcal matter or paper can be detected in the mixture. The earth can be dried and used again several times for the same purpose. It is found, however, that the 'compost,' as it is termed, is not a valuable manure, and in fact is not a richer manure than good garden mould. Brick earth, loamy earth, and garden mould yield the best results; while chalk and sand are almost useless. The receptacle of the earth closet is either a movable pail or a vault. Each pail is made large enough to hold from fifteen to twenty charges. The earth is stored in a hopper behind the seat, from which it falls into a valve. The valve is in connexion with a handle or with the seat, in such a way that pulling up the plug or removal of the weight of the body tilts the valve and upsets the earth on the contents of the receptacle. On pressing down the seat or letting go the plug, the valve is again charged with earth from the hopper.

The objections to the conservancy system are:

(i.) The excretal matter is stored up for a longer or shorter time about the house, and thus in many cases becomes a serious nuisance.

(ii.) As carriage of the stuff away is necessarily expensive, there is a tendency to cut down expenses by allowing the refuse to accumulate.

(iii.) None of these plans produce a manure which will in any way repay the cost of its removal to long distances; and none have been made to pay the cost of working with the exception of the pail system, in which no admixture of any kind is allowed with the excreta.

(iv.) The use of the dry earth system does not do away with the necessity for sewers, for they are still required for the removal of foul waters.

Water Carriage System.

Sewers are pipes used for the conveyance of foul waters, and should therefore be quite impervious. The large sewers are oval in section with the narrow end downwards, and are built of brick and cement; while the small sewers are constructed of earthenware pipes. On no account should sewers have a square section, as dirt is liable to accumulate in the corners. Where possible the use of brick sewers should be avoided, as they allow the foul water to soak through and contaminate the surrounding ground. Moreover, sooner or later they are perforated by rats.

Sewers should be ventilated, the proper allowance being eighteen ventilators to the mile. The ventilator should reach from the top of the sewer to the level of the street; and its opening be covered with a grating, below which there should be a receptacle to catch mud and solid street washings. If there is a sufficient number of these ventilators, foul air will never accumulate in the sewers to such an extant as to be a danger, for it is being constantly diluted with the fresh air which is allowed free circulation by the ventilation. The suggestion that sewers should be ventilated by pipes running up the sides of houses is not a good one, as the plan is found in its working to be less efficient than that described above. Another plan that has been proposed is to connect the sewers with the flues of furnaces, in order that the draught up the chimney should draw the foul air through the sewer. On one occasion on which this suggestion was carried out, an escape of coal gas into the sewer took place, which blew the gas-works down.

Sewers should, if possible, be laid quite straight, and at every bend there should be a manhole or inspection chamber. They should have a fall of 1 in 244 to 1 in 784, according to their size; and the flow along them should be at least 2 to 3 feet per second.

The velocity of flow along a sewer may be calculated from the formula,—

$$v = 55\sqrt{2fh},$$

where v = velocity, f = fall per mile, and h = hydraulic mean depth; which, for a circular sewer running half full, is equivalent to half the radius.

The house drain should be made of glazed earthenware pipes, 4 to 6 inches in diameter, laid with a suitable inclination upon a bed of concrete, 6 inches deep. The joints, both in the house and street sewers, should be most carefully attended to during the construction, as neglect of this important point may lead to leakage of foul matter subsequently.

In laying the house drain the socket ends of the pipes should look upwards, that is, in a direction opposite to that in which the water is flowing in them. The joints should be carefully cemented all round, and none of the cement should be left sticking up inside the pipes opposite to the joint, for it may subsequently lead to accumulation. In Stanford's patent pipes the joint is made with a coating of bituminous material. Before being put together the ends of these pipes require greasing.

Among the mistakes which builders may make in laying pipes, the following may be noted amongst the more common :

(i.) The pipes are laid dry, that is, without any cementing substance, but are simply fitted into one another.

(ii.) The joints are made with clay. With this material the joints are never watertight even to begin with, and the defect only becomes worse with use.

(iii.) Only the upper portions of the joints are cemented, the lower parts being left dry. In order to prevent this Jennings devised a cradle, which is filled with cement, and then the pipes are laid in it.

(iv.) The drain is not laid on a bed of cement, so that should the ground sink under it the joints will crack, and then leakage of foul matter follows.

Traps.—(i.) Between the house drain and the street sewer there should be a trap. Under the old plan of drainage this was usually a dipstone trap, which consisted of a square chamber built of brick and lined with cement, and covered with a stone slab, from the under side of which a stone partition hung down into the water which the brick chamber contained, and prevented the reflux of air from the sewer into the house drain.

(ii.) The place of the dipstone trap has now been taken by an intercepting stoneware syphon trap, which is a U-shaped glazed earthenware pipe. From the top of the limb nearest to the house drain, a pipe runs up to the level of the ground and acts as a ventilator, while coming off in an oblique direction from the top of the other limb is another short pipe, the end of which is kept closed by an earthenware plate. This is known as the 'raking arm,' and it is intended to allow of accumulations being cleared away.

(iii.) Fashioned after the shape of the dipstone trap is the lip trap, which consists of an iron box covered with a grating and furnished with a lip or partition, which dips below the surface of the water. The principle of this trap is the same as the dipstone.

(iv.) The bell trap consists of an iron box, the bottom of which is perforated by a pipe which terminates by an open mouth in the box. The latter is fitted with a perforated cover, to the under surface of which is fixed the bell, which, when in position, fits over the open mouth of the tube described above, and dips below the surface of the water. The objections to this form of trap are: (*a*) That the water evaporates in dry weather and the trap is unsealed; (*b*) it favours the accumulation of dirt; (*c*) being fitted with a movable top, the latter may be removed, and if from carelessness it is not replaced the trap is rendered useless.

(v.) The syphon trap is simply a tube bent into the form of a U.

(vi.) The anti-D trap is a syphon trap with a square outlet arm. The lower end of this trap is slightly constricted. Both syphon and anti-D trap may be fitted with a movable screw cap.

(vii.) A gully is a stoneware syphon trap, in which the space below the dip or trapping piece is much deepened in order to intercept any solid matter. Dean's Yard gully has a square bottom, and is fitted with a box inside, which can be lifted out by an attached metal rod. The box is intended to collect solid matters, like grease, soap, sand, &c.

A manhole is an inspection chamber, placed usually on the bend of a drain, or on the house drain before it empties into the sewer. The ordinary form of manhole consists of a chamber formed of brickwork, set in cement, and large enough to allow a man to descend into it. The house drain and tributaries opening into it run along the floor of the chamber. In the manhole the pipes which convey the foul water, instead of being circular, are half or channel pipes, and thus admit of their contents being inspected. The manhole is covered with a closely fitting iron door.

Closets.—Besides the pan and short hopper water closets, the other chief forms are:

(i.) *The Valve Closet.*—The basin is bowl shaped, and fitted with a watertight valve, which, by means of the plug, moves in a small box called the valve box. The latter leads into a trap, usually of the anti-D variety, to which is fitted the soil pipe. Water is supplied to the basin by a flushing rim, and the basin is provided with an overflow pipe, on the lower end of which is a U-shaped bend. The overflow pipe opens into the valve box behind the valve, so that when the latter is swung back by pulling up the handle of the closet, should the trap become unsyphoned, it may not allow foul air to escape up the overflow pipe into the house. Unsyphonage of the overflow pipe may be prevented in several ways : (*a*) By connecting the pipe which supplies the basin with water with the overflow pipe, so that the latter is supplied with water at the same time as the basin. (*b*) By carrying a ventilating pipe from the valve box to the open air. (*c*) By making the overflow pipe discharge externally. (*d*) By doing away with the overflow pipe and allowing the basin to overflow into a safe tray.

(ii.) *Wash-out Closets.*—The basins of these closets are shallow, and open into the trap on one side, instead of below. The junction of basin and trap is marked by a sharp rim. The objections to this form of closet are: (*a*) Owing to the shallowness of the basin, the layer of water which it holds is insufficient to prevent its being soiled by the excreta. (*b*) Fæcal matter and paper are apt to lodge at the outlet of the basin, and are difficult to wash away.

(iii.) *Long Hopper Closet.*—The basin is conical, long, and narrow, and holds but a very small amount of water. It terminates below in a syphon trap. The objections to it are : (*a*) That the layer of water in the basin is too small. (*b*) The water is supplied by an inlet arm instead of a flushing rim, by which it is simply whirled round the basin without cleansing it.

The Soil Pipe.—The joint between the soil pipe and trap is found to be one which if it gives way is more serious in its effects than that between the trap and basin. Hence, where possible, the trap should form part of the soil pipe, and the joint be between the trap and basin. The soil pipe should be carried up full bore above the roof, and allowed to terminate either by a free opening or be covered with a cowl. There should be no trap between the junction of soil pipe and house drain.

Sinks.—The outlet from sinks should be covered with a grating, and the waste pipe fitted with a syphon trap having a screw cap. The pipe should be carried through a wall and made to discharge over a gully.

Baths.—The waste pipe of a bath should be treated in the same way as that of a sink. Baths should be fitted with safe trays to catch the overflow, the waste pipes from which should be carried through the wall and made to discharge externally. Their open mouths may be covered with a little brass flap.

Sewage.—Each adult male passes about 4 ounces of fæces and 50 ounces of urine per diem. Women and children pass on an average about 2½ ounces per head of fæcal matter in 24 hours.

The composition of urine and fæces passed in the 24 hours is as follows (Lawes & Gilbert.)

	Fresh.	Dry.	Mineral.	Carbon.	Nitrogen.	Phosphates.
Fæces	4·17 oz.	1·041	·0116	·443	·053	·068
Urine	46·01 oz.	1·735	·527	·539	·478	·189

From this it is evident that the urine in all important constituents contains considerably greater amounts than the fæces. Lawes & Gilbert put the annual value of sewage per head at 6*s*. 8*d*., of which 5*s*. 6*d*. is due to the urine. In all manures of this kind, the actual manurial value is never as much as the theoretical price is fixed at.

The valuable materials in sewage are nitrogen, phosphoric acid, and potash. In 100 tons of liquid sewage, the dissolved matter is valued at 15*s*. and the suspended at 2*s*.

Disposal of Sewer Water:

(i.) By discharge into running water. In its crude state this is now illegal.

(ii.) By discharge into the sea.

(iii.) By precipitation. In this method an attempt is made to purify the sewer water by treating it with chemicals before turning it into the river, but none of these plans effect this completely.

Among the many precipitants which have been suggested, the following may be mentioned :—Lime ; lime and perchloride of iron ; lime, carbon, and soda ; lime and clay ; carbolate of lime and magnesia ; lime, tar, and chloride of magnesium ; superphosphate of lime and magnesia ; mono- and di-calcic phosphate ; sulphate of alumina and zinc.

The manure which results from precipitation possesses the following value :

	Per lb.
Insoluble phosphate of lime	1*d.*
Soluble phosphate of lime	2*d.*
Potash	2*d.*
Ammonia	8*d.*

(iv.) By filtration through :

(*a*) Ashes and charcoal. The effluent contains a large amount of ammonia and salts, and no oxidation to nitrates occurs.

(*b*) Through sand and chalk. In the effluent the carbon is reduced from 4·3 to ·6, the nitrogen from 2·2 to ·065, while the nitrates have increased from 0 to 3–5 per 100,000.

The rate of filtration should not exceed 5·6 gallons per cubic yard in the twenty-four hours.

(v.) By the application of sewage to cultivated lands (sewage farms).

There are several methods of applying the sewage, viz.:

(*a*) By converting the land into water meadows, *i.e.*, to keep the land under sewage water.

(*b*) By the hose and jet.

(*c*) By subsoil irrigation.

(*d*) By the catch-water system.

(*e*) By the pane-and-gutter system.

(*f*) By the ridge-and-furrow method.

One acre of a sewage farm disposes of the sewage of one hundred persons.

The objections which have been raised to sewage farms are :

1. That they cause an offensive smell. This may be true if they are not carefully managed.

2. They may generate malarial disease. The water meadow plan by turning the land into swamps is certainly liable to produce this result.

3. That they may give rise to diseases, such as typhoid and dysentery. This has not been proved.

4. That they raise the death rate. This certainly does not hold good, for at Norwood and Croydon, where there are sewage farms, the death rates are only 12 and 20 per 1000.

5. That they destroy the purity of the atmosphere. There is no foundation for this.

6. That they may spread parasitic disease. There is no evidence to substantiate this.

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[*See over.*

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