MANUALS OF HEALTH.

THE HABITATION

RELATION TO HEALTH.

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HABITATION IN RELATION TO HEALTH.

CHAPTER I.

INTRODUCTION.

"A HOUSE to live in," "a roof over our heads," seem to inhabitants of civilized countries so necessary that they hardly realize the possibility of being without them; or, at all events, they associate such a condition with extreme poverty and misery. And yet it would appear to have been comparatively late in the history of the human race that artificial shelter was sought at all. In the warmer regions, in which man seemingly had his origin, the reasons that made him seek shelter were probably the desire for protection from the heat of the sun, from heavy rains, and from the attacks of wild animals; and the earliest habitations were most likely trees and caves. Both history and antiquarian researches have made us acquainted with races of Troglodytes, or dwellers in caves or holes in the ground, whilst there are existing races who still live in trees, as our own remote ancestors probably did. This was also, in all likelihood, a general condition at one time, as everything goes to show, that man was a fruit-eating animal in the early part of his life-history, and that his taste for animal food was a later acquisition, most probably arising out of special circumstances. When artificial shelters began to be made they were doubtless of a most primitive character, consisting either of holes specially dug, or of boughs of trees, palm-leaves, bunches of grass, &c., put together. Many races have no better shelter at the present day; the Andaman islander, for instance, puts up a few upright sticks, upon which he places a sloping roof of boughs or leaves, which is all he knows of a house. Their climate is warm, and frost and snow are unknown; but on the other side of the world, in Tierra del Fuego, the natives are not better provided, and even go about quite naked, although their climate is a most wretched one, with storms of wind, rain, snow, and often severe frosts.

Among the natives of the Arctic regions, where there are no trees, comfortable dwellings are built out of snow, a plan which has probably been resorted to for countless ages.

Among nomad or wandering nations, tents of some kind or other must have been early resorted to, probably consisting in the first instance of skins of animals, stretched on a wooden pole or over a frame. The tents of the Romans were apparently of this kind, and the kibitka, used in Russian Tartary of the present day, is also of the same nature. The Hottentot kraal is a framework of branches, covered with sods of earth.

Of materials for more permanent buildings, wood was probably first used, or in the countries where they grow easily, canes, such as the bamboo. It is impossible to exaggerate the immense convenience and usefulness of this plant to natives of tropical climates. Huts can be made of it in a very short time, affording both good protection from sun and nd excellent ventilation. Wooden houses were formerly common everywhere, especially where forests were abundant, and in many of our colonies in the present day wood forms the staple material for building. The gradual disappearance of forests and the great danger from fire probably both contributed to the use of brick or stone, of which most modern buildings are now made. It was long the practice, however, even after the use of bricks became general, to build houses of a wooden frame, with the spaces between the beams filled in with brick. This plan is still in use in the present day in many places, although objected to in towns on account of danger from fire. Mud, or concrete, has also been used with advantage in the construction of dwellings, being both warm and cheap, and admitting of useful arrangements for ventilation, which might be more generally resorted to were their value better understood.

In considering the question of habitations in relation to health we touch upon some of the most important points affecting the well-being of both individuals and communities. It is true that we require shelter of some kind in almost every climate, as a protection against heat, cold, or wet,—putting aside the danger of attacks from men or animals,—and were we deprived of shelter, much misery and death would be the consequence. Yet it must be understood very clearly that shelters, especially in the form of most houses, are by no means an unmixed good, and that a large amount of the disease and death which so sorely afflict our population is due to causes arising in the very dwellings which are supposed to increase their comfort and well-being. Our greatest enemies are *foul air* and *foul water*, the former always and the latter mostly getting its foulness in our dwelling itself or its immediate neighbourhood. Could we banish foul air from our houses and secure a proper supply of pure water, we should be able to reduce the deaths in the United Kingdom to about one-half their present number, and also lessen in proportion the amount of sickness and consequent loss of useful work which so often throw families into distress and destitution. At present one person in every forty-five dies in this country every year, and in some places, and at certain times, one in every twenty. Even of the lower of these two numbers a great many die who might be preserved if proper measures were carried out to prevent disease spreading. Thus, whilst twenty-two persons die out of every 1,000 in each year, this number might be at once brought down to fifteen, and in course of time to even less. Again, of all the children born in this country one-seventh die before they are a year old, and more than one-fourth before the age of five; whilst in the more crowded districts the rate is often doubled. This terrible infant death-rate is surely a reproach to our modern civilisation, since it is in a large measure due to causes under our own control. Now, although much evil must be allowed to come from bad and insufficient food, exposure to cold and wet, insufficient clothing, and the like, it must be insisted upon that these have not been by any means the most active causes of disease and death. The foul air which we breathe again and again in our bed-rooms at night, in school-rooms and work-rooms during the day, air poisoned with the waste matter from our own bodies, has proved by far the most dangerous enemy; when we add to this the evil smells and poisonous gases arising from closets and drains on account of the imperfect way in which they are constructed, we have another source of danger to life and health of the most serious character. The water, also, that we drink, even if it be pure when brought to us, is too often made dirty and dangerous from causes arising in our dwellings, from dirty cisterns or from sewer-gas getting access to it through the waste-pipe being connected with the drain; or, if the water be from a well, from sewage actually finding its way directly into it.

There are other causes of unhealthiness about our dwellings which are, however, less within the control of the occupier, and it may perhaps make the matter plainer to state the various causes together, with a few explanatory remarks :—

Causes of Unhealthiness of Dwellings.

1. *The Site of the Dwelling.*—The house may be damp, or even exposed to floods; it may be so placed as to render it probable that the drainage of other dwellings may flow into its site; or it may be on *made* soil, that is, mixed rubbish of various kinds.

It may be exposed to the weather, to cold winds or rain, or may be deprived of light and air by the too close neighbourhood of other buildings.

It may be placed near unwholesome places, such as foul streams or offensive trades.

2. *The Materials of which the Building is made and the Way in which it is Built.*—The materials may be bad: the walls may be too thin, so as to be cold,—or so made as to let the wet through,—or the foundations may be imperfect, so as to allow dampness and soil-air, dangerous to health, to rise.

The house may be badly arranged, so as to deprive some parts of proper light and air.

3. The *Conservancy* arrangements may be bad. By conservancy is meant the provisions for carrying away excreta and foul water, and also the removal of refuse.

This includes bad sewerage arrangements, either in the position and laying of the pipes or in their material and workmanship. They may be untrapped or badly trapped, so as to allow free access of sewer-gas to the house. The closets may be in a bad position, so as to render it difficult or impossible to ventilate them properly. The sinks, waste-pipes of cisterns, bath-rooms, laundries, &c., may be in direct communication with the sewers or cesspool.

4. The *Water Supply* may be defective or bad in quality.

The above are points in which the occupier is often without remedy unless he leaves the house and seeks another. Unfortunately he may be unable to make a choice, and circumstances may force him to put up with the unfortunate conditions in which he finds himself. Some of them are, doubtless, capable of remedy, and the law can compel his landlord to apply the remedy when it is possible.

The other causes of unhealthiness are those chiefly within the power of the occupier himself.

5. The Air may be rendered foul by several causes:

By too great crowding of persons in the house, or in certain rooms of the house.

By a want of ventilation or proper change of air, in consequence of keeping the windows and doors shut, and stuffing up the chimneys when not used for fires.

By dirtiness of the premises; by accumulation of dirty clothes or decaying articles of food.

By inattention to the state of sinks and closets and proper emptying and cleansing of utensils.

6. The drinking-water may be rendered foul by various causes within the house itself.

These, the most serious causes of disease, are generally quite within the control of the occupant, and may, in most cases, be removed by the use of very simple precautions.

Having thus briefly stated the case, I propose now to go more into detail on each point.

CHAPTER II.

THE SITE OR SITUATION OF THE HABITATION.

THIS part of the question includes several points, viz.:—

1. The ground on which the house is built.

2. The exposure of the house with reference to the wind, air, and light.

3. Its relations to its surroundings, viz., the presence or absence of other dwellings, or of any natural or artificial condition that may affect health.

As I have already said, the occupant or tenant is too often so tied down by the circumstances of his trade or his means, as to make his choice of a house a very limited one, so that he must take it as he finds it, particularly in the matter of site, and make the best of it. Still, when he does have a choice it is well he should know how to choose; or, at least, to understand the most important things to avoid in making his choice.

Taking the above points separately, we will now look at,—

1. *The Ground on which the House is Built.*—The points to be aimed at are to get a place that shall be

either naturally dry, or at least easily drained, and into which drainage from other places is not likely to flow. For this purpose all low-lying swampy places should be avoided. If the ground is generally flat, advantage should be taken of any rising ground, however slight, that promises easy drainage. Hollows, or places lower than the surrounding parts, should be avoided, both because they are damp and generally unhealthy, and also because in winter they are often very cold. Thus potatoes are often frosted in a hollow, when those on higher ground are untouched. The slope of a hill is a good situation, provided the house be built on a terrace or spur, a little way off the hill itself. If built close in to the hill it is always damp, and generally unhealthy, besides being liable to serious damage in the event of heavy rains or landslips. Again, the banks of rivers, unless the ground is somewhat raised above the highest level of the stream, are to be avoided, both on account of occasional floods and for fear of continual damp.

As regards the soil or ground itself, we ought to select a porous soil, such as sand or gravel, if possible; a soil which allows all water to run away freely from about the house. Next to this kind of soil would be any rock, such as granite, clay-slate, limestone, sandstone, or chalk, which generally admit of easy drainage on account of good slope. Stiff clays and loams had better be avoided, although they are not necessarily unhealthy if proper drainage is carried out. Perhaps the worst combination is a shallow layer of gravel or sand, with stiff clay beneath. What are called *alluvial* soils, or arable land, are generally to be avoided; also reclaimed lands at rivers' mouths and the like.

In towns, the chief danger is from *made soils*,—that is, miscellaneous rubbish shot into vacant spaces; this too often forms the chief soil on which many of our towns are built. The report on the town of Liverpool, made some years ago by the late Dr. Parkes and Dr. Burdon Sanderson, gave a graphic account of the strange mixture of stuff that they found in the *made soils* of that town. It is certainly not safe to build upon such sites until the rubbish has been exposed to the sun and air for at least *two years*, and even at the end of that time various organic matters, such as vegetable refuse, may still be found decaying.

Another thing to notice is the distance of the *ground-water* from the surface. The *ground-water* is the great underground lake or sea which exists everywhere at different depths from the ordinary level of the ground, which supplies the water found in wells, and which is the great danger and cause of floods in coal and other mines. In almost any place, if we dig deep enough, we come to water; but in some places we come sooner upon it than in others: the ground-water is, therefore, said to be *higher* or *lower* in one place than another. Its height can be easily measured by finding how deep down it is to the surface of any shallow well in the neighbourhood. In some places water is found at a foot or two from the surface; in others not until we go down 15 feet or more. It varies with the amount of rainfall, being higher some time after heavy rain than after dry weather. It is plain that if the water is too near the ground-level the place will be damp, therefore a low ground-water level is to be wished for. If possible, the water ought never to be nearer the surface than 5 feet. There is good reason to believe that sudden changes in the height of the ground-water level are bad for health: a place, therefore, where the level of water in a well is apt to rise and fall a good deal, and particularly if the change be sudden, is not a good site. Although the above remarks apply more specially to country places, they still have their importance with reference to towns also; for it not unfrequently happens that one part of a town may be less healthy than another, on account of its situation being lower and the level of the ground-water higher. Again, the choice of one town rather than another as a place of residence may depend upon this condition,—for it has been shown by statistics that a proper system of drainage, by which the ground-water level has been lowered, has been followed by greatly-improved health among the inhabitants. Consumption,—a disease which is so fatal in this country,—is very much affected in this way; and Dr. Buchanan has shown that it has been diminished, in consequence of lowering of ground-water level, to the extent of *one-half* in some towns,—as, for instance, Salisbury; and the same thing has been observed in America,—as, for instance, Philadelphia. Another good example of the effects of drainage (meaning by this the carrying-off of water from the soil) is the almost complete disappearance of ague from this country, where it was in former times so common. When the outflow, however, is interrupted, the ground-water rises, and the disease may reappear. This has often been seen in hot climates, such as India; and it appears to have occurred even in this country, under certain circumstances. Such an occurrence is a warning not to relax our sanitary efforts, but to continue them with watchfulness and care, as the only conditions under which health can be preserved and a heavy death-rate prevented.

For the remedying of the above evils, we have several plans open to us. *First:* Good *subsoil drainage*, in order to dry the ground if we find evidence of too high a ground-water. *Second:* Sufficient surface-drains to carry off both ordinary water and storm-waters, that neither may lodge in or near our site. Of course, a great part of the ordinary rain-water would be saved for use,—at least, in country places, where there is no general water-supply. *Third:* The encouragement of vegetation near the house, if it be situated in the country. Many people think that trees, shrubs, and even grass, are unhealthy, but this is really not the case. Trees, if not too thick, are generally an advantage, as they are certainly a beauty, for they tend to dry the soil; whilst grass is most valuable in using up the organic matter in the soil, which might, perhaps, become hurtful.* *Fourth:* By proper attention to the foundation of the house, and so preventing dangerous vapours rising out of the ground into it. On this point we shall have something more to say further on.

2. *The Exposure of the House with reference to Wind, Air, and Light.*—The house may be exposed to excessive winds, or it may be deprived of sufficient circulation of air; it may also be too much exposed to the glare of the sun, or it may be in too dark a situation. It is obvious enough that in this climate exposure to a prevailing cold wind is undesirable, and that a spot more or less sheltered is to be preferred. It is better, however, to have a shelter through which some air passes, such as a belt of trees, than a rising ground or hill, which may prevent the air circulating freely round the house; and it is also well to have

* Certain plants have more active influence than others in drying and cleansing the soil; thus the *Eucalyptus* genus, which includes many species, and is represented by the well-known *blue-gum tree* of Australia, is noted for this quality; whilst the common sun-flower is another plant, even more familiar and still more easy of cultivation, which has a powerful influence in the same direction.

the entrance door, either back or front, protected from the prevailing wind, either by actual position or by some special protection, such as a porch. Thus, it is not desirable to have the door on the south-west side, in most places in this country, as that is the quarter from which most wind and wet come. On the other hand, it is a most necessary thing that there should be such free space round a house, that the air can sweep round it, and be admitted at all sides, as we may find convenient.

As regards light, it is seldom in this country that we suffer from too much exposure to the sun,—it is rather want of light that makes itself felt, particularly in our towns. It ought to be remembered that light is not the least important agent in the growth, development, and maintenance of our bodies, and that both plants and animals deprived of light become blanched and weak, and often fade away altogether. One of the reasons why Europeans have suffered in health in tropical climates has been the practice of shutting themselves up in darkened rooms during the day-time. No doubt careless exposure to the sun is bad, but if proper precautions are taken it is found that those who move freely about in the air and light are much more healthy than those who shut themselves up in the dark for fear of the sun. We must take care that the sun has free access to our house, and it is a good rule that the sun, as long as he is visible, should strike some part of our house. As regards the particular aspect of any part of the house, if care is taken that the sun should have access to it pretty freely in general, the selection as regards rooms will depend chiefly on convenience. Thus, a room to be used as a study, or a workroom requiring a steady light, should face the north or some point between north-west and north-east. A morning room, such as a breakfast-room, would face north-east to south; whilst a drawing-room would face south-east to north-west, for at least one of its aspects, if there be more than one. Store-rooms, dairies, larders, &c., should have a northerly aspect, as coolness in these is desirable; in most cases also kitchens ought to have a similar aspect, as making the atmosphere less oppressive where large fires are necessary.

3. *The Relation of the House to its Surroundings.*—If we have to deal with a separate house or cottage in the country, the first thing to see is, whether or not it be too near any other dwelling, or any stable, byre, &c., from which drainage may pass into its site or neighbourhood. Thus, a cottage lying at a lower level than another near it is exposed to the drainage from the one above. This is a source of danger, and ought, if possible, to be avoided. The neighbourhood of cesspools, middens, accumulations of filth or refuse of every kind, ought to be shunned; as ought also the banks of foul streams or ponds or places into which sewage finds its way. In towns, streets which are wide and open to the air, both in front and back, ought to be selected, if possible,—although in this case the occupant is often compelled on account of expense, the requirements of his work, and the like, to put up with a situation in every way undesirable.

CHAPTER III.

THE HOUSE ITSELF.

This chapter will include the following points:—

1. The *Materials* of which the house is built.

2. The *Way* in which it is built, with reference to the following:—

a. The preparation of the foundation.
b. The state of the outside walls and roof.
c. The inside walls, ceilings, and floors.
d. Arrangement of the parts of the house.

All these are important points, and ought to be inquired into by the intending occupier.

1. The *Materials* of which the house is built.

In this country *brick* is the most common material, but in some parts *stone* is used where it is abundant. *Wood*, either alone, or along with bricks, is also used in country places, but it is generally objected to in towns on account of the danger of fire. *Mud*, or *unbaked clay*, is sometimes employed, and, of late years, the use of *concrete* or *cement* has been resorted to.

Corrugated *iron* is also sometimes used, but it has the disadvantage of being cold in winter and hot in summer; this, however, may be obviated by having an inner skin of wood, and the interval filled up with saw-dust or some other non-conducting material.

2. *The Way in which the House is built.*

a. The Preparation of the Foundation.

I have already mentioned that very little care is too often taken in selecting the ground on which to build a house; equally little care seems to be taken about the foundations of the house itself. The dangers to health from a bad site are due, so far as the house itself is concerned, to the fact that damp and unhealthy vapours (or *emanations* as they are called) rise into the house itself. There would be a danger ot this even if the air within the house were always of the same temperature as the air outside, but, when we remember that in almost every instance the air inside the house is *warmer* than the air outside, the danger becomes clearly greater. When air is heated it rises, so that the upper part of a room is always hotter than the lower ; this is caused by the colder and heavier air falling down and pushing up the warmer and lighter air. Now, the consequence of such an up-current is that it draws other air behind it from some part or another, just in the same way as a pump does water. Now, if the floor of the house be air-tight, the heated air in passing up to escape at the chimney or other opening will draw air from openings to the outside, such as a window or a ventilator. But if the floor be not air-tight and the windows be shut, and there be no ventilation, then, as air must be got from somewhere, it will be drawn through the floors from the soil on which the house stands. So that every house tends to act as a suction-pump and draw air out of the ground. Now, this ground-air is very impure, and its impurity, although a good thing for plants, is a very bad thing for men and animals,—therefore we ought to prevent it getting into our houses. When it passes up into the open air it is soon mixed with large quantities of fresh air, and its bad effects to a great extent prevented, but when it passes into our houses, where the air itself is often impure enough from other causes, it comes in a much more concentrated form, and cannot be diluted so as to be rendered harmless. In most instances, however, little or no precaution is taken to prevent this : houses in towns are built on made soil, and cottages in the country are planted on the bare ground, without even stubbing out the gorse roots, &c., which may be present. The least evil that results is more or less constant damp, not to speak of the more actively dangerous emanations that often arise. In order to prevent this state of things every piece of ground ought to be carefully prepared before-hand, and an impervious (that is, both air and water tight) layer ought to be laid down. The best is a firm layer of cement or concrete, to which is sometimes added one or more layers of charcoal; but, if the expense of that were objected to, a layer of well-puddled clay is probably the next best thing. In some places it is necessary to raise the building on arches to keep it sufficiently clear of the ground,—but in any case there ought to be some distance between the foundation and the floor of a living room, and the space so left should be ventilated. When cellars are constructed under a house they add to its healthiness, provided they are properly made, have an impervious flooring, and are thoroughly ventilated.

The next point is the way in which the foundation brickwork is arranged. This ought, of course, to be sufficiently solid and deep enough in the ground to give firmness to the whole building. But the situation and the nature of the soil may lead to great dampness in the foundation, and in order to prevent this rising up the walls, it is necessary to lay a *damp-proof course* along the top of the brickwork as it comes to the level of the ground. This course is either glazed tile, made specially for the purpose, or slate. The latter was used by the Romans in their masonry, and sometimes hard flat stone was substituted. The damp-proof tiles, however, are to be preferred, as answering the purpose better, and also because they can be made hollow and used as ventilators below the floors. By this means the damp is effectually prevented from rising, and the stability and healthiness of the house more certainly ensured.

b. The State of the Outer Walls and Roof.—Our object is to get such a wall as shall effectually keep the wet out and the heat in, so far as our climate is concerned. For these ends our wall must be sufficiently thick, and as little porous as possible; for if the walls be too thin, the heat of our fires goes away too quickly through them, so that fuel is wasted while the inmates shiver; whilst if the walls be too porous, rain will beat in from without, and damp rise up from below. Houses that are built of stone have fewer of these dangers to contend against, but the majority of our dwellings being of brick, we must consider the special points connected with that material. In many countries crude or sun-dried bricks are employed, but these are but ill-suited for our climate, and we have therefore to do with baked or kiln-dried bricks. Ordinary bricks are 9 inches long by 4½ inches broad and 2½ inches deep, giving a total bulk of about 101 cubic inches. Now this, although a hard and unyielding substance, is by no means solid; it is, on the contrary, very porous or full of small holes and air-spaces, so that air can be easily driven through it. Some idea of the extent to which this can be done may be got by knowing that it is possible, with very little contrivance, to blow out a candle through a 9-inch brick wall. If this be so there must be a large amount of *space* in the brick, and we are to remember that where air can pass water can get in. Now it has been ascertained that rather more than one-quarter of the bulk of a brick is really air-space, and that if a brick is soaked with water it can hold in that space (the air being driven out by the water) nearly 28 cubic inches, or the tenth part of a gallon of water. In this way a cottage-wall, only 16 feet long by 8 feet high, and only *one* brick thick, might hold 46 gallons of water! The dangers from dampness here are plain enough. We have already seen that the damp rising from the ground may be prevented by laying damp-proof courses on the foundation-walls, but as damp may be driven in sideways, other means of protection must also be used. Of these the following are the most generally employed:—

1. Having a double wall with a space between the outer and inner walls.

This ought always to be resorted to, even if other plans are added on. With a damp-proof course at the bottom of the space and openings in the outer wall, sloping outwards, all the wet will be carried off or confined to the outside wall. The bonding-plates between the two walls should also slope downwards and outwards (as arranged in Jennings' bonding-tiles), otherwise the wet will pass across them to the inside.

2. The wall may be plastered or cemented outside.

This is a good plan, provided it is done when the bricks are dry, as otherwise the wall is kept damp and the plaster cracks off. Painting the outside with silicate or indestructible paint is a great protection. Such paint may also be applied to the bricks themselves, even without plaster.

3. The wall may be hung with slates or tiles overlapping. This is a plan much resorted to and very effectual. Planks of wood also laid on in a similar way, and painted or varnished, make a good protection.

It is, of course, to be understood that the bricks themselves should be of good material to begin with, otherwise our precautions may prove of little avail.

The roof ought to be carefully looked to, as defects in it are a common source of dampness. *Slate* or *tile* is the most common article used for roofs, and of these the former is the best, for when well laid on it leaves nothing to be desired. *Thatch* forms a good roof, being warm and dry, but there is danger from fire, and, if not well looked after, it is apt to be destroyed by birds and vermin. In some parts of the country flat stones are used, as in the red sandstone districts, when the stone can be easily split. Except for danger of fire, wood covered with tarred felt or canvas makes an excellent roof. The slope of the roof ought to come out some distance beyond the walls, and be provided with a good roan, or gutter, so as to throw off the rain well away from the house. A frequent cause of damp is a leak by the side of a chimney-stack, or where a tank is set in the roof; those parts should be very carefully looked to and properly secured.

c. The Inside Walls, Floors, and Ceilings.—We have considered shortly the plans for keeping the outside walls dry; or if that is impossible of preventing the wet reaching the inside. The inner walls ought to be protected in some way, although some persons have raised objections to this, saying that the porosity of the walls ought to be kept, so as to make the ventilation of the house more complete. This might have some little reason in another climate than ours; but I think it would be difficult to carry it out here, without making the house damp and uncomfortable. It is, therefore, better to cover the walls in some way on the inner side, and to trust to other methods for the ventilation. There are various ways of treating walls; in some cases they are merely whitewashed over the bricks. This is not a very good plan, for it does not do away with the porosity of the bricks, and it leaves a comparatively rough surface for dirt of various kinds to lodge. Should this plan be used, the wash ought to be frequently renewed. It is better to provide a surface that shall be smooth, leaving as few roughnesses as possible, and at the same time be capable of being thoroughly washed. For this purpose two plans can be employed: the walls may be covered with glazed tiles, an excellent plan for kitchens, sculleries, dairies, larders, &c.; or they may be plastered and then painted, either with ordinary oil-paint or with some of the forms of indestructible paint. Ceilings ought to be treated in the same way. Papering walls is so common a practice that it may be difficult to persuade people that it is not a good one. Where the paper is a glazed one, or when it is covered over with a varnish, it is less objectionable, as it does not leave much room for dirt to stick to it; but the flock-papers, which are often used in the best houses, and the cheaper papers in use in poorer houses, are both bad, as they form receiving places for dirt which it is next to impossible to get rid of. If painting or varnishing be objected to on account of the cost, I think lime-washing is better than paper, as it can be more easily cleaned and renewed. At the same time it must be remembered that the mere putting on of a fresh coat of lime-wash over an old dirty one is not *cleaning* a wall, it is (as it has been rightly called) merely putting "white dirt over black." Before lime-wash is renewed the wall ought to be well washed beforehand, in order to remove any dirt that may have settled on it. When paper is used in a house it is not infrequent to find that a new paper is merely pasted over an old, when the room is to be done up afresh. This is repeated again and again, until sometimes half-a-dozen papers are found one under the other. Now, each of these papers has taken up its share of dirt, and each has been laid on with a fresh supply of paste, so that if the walls get damp, all this has a chance of rotting and fermenting, and so becoming a source of ill-health. In no case ought a new paper to be laid over an old one, but the old one ought always to be scraped off first. This is no doubt an additional expense, but it is a good investment for the sake of health.

With reference then to walls and ceilings we may sum up in this way:—Cover them, by preference, with some material that has a smooth surface, and allows of washing. Lime-washing is to be preferred to common, unglazed, or flock-papers. If papers are used, varnish them if possible. When papers are renewed, always scrape off the old paper before putting on the new.

Floors.—Floors are either of wood, stone, or tile. Stone or glazed tiles are very good for kitchens, sculleries, lobbies, and the like, but are apt to be cold for living-rooms. Of all floors the most comfortable is wood, and the best are of hard wood, closely fitting. Such a floor, however, is expensive, and in ordinary circumstances common deal is used. In too many instances floors are very badly made, with ill-seasoned wood, that soon shrinks and gapes. If the floor be over the ground, unprotected, or over a cellar which is unventilated or allowed to be a receptacle for refuse, all the foul vapours will rise into the room. Or if there be a closed space below the floor, between it and the ceiling of the next room, this forms a place for various kinds of dirt to collect, which may afterwards be a source of annoyance or danger. Even if a floor be made of deal, it may be made much better by being well caulked in the seams with tow, and varnished over: this allows of its being well cleaned by mere sweeping or dry scrubbing, and, if it be necessary to wash it, it dries much quicker. The damp arising from ordinary floors, when washed, is a source of unhealthiness that has not been sufficiently acknowledged, although its effects in hospitals and on board ship have been often noted. Hard stone and glazed tiles have in this way great advantages over common deal, if it be not caulked and varnished. We may sum up the question of floors in this way: let us have a floor that gives a smooth surface, into which water will not soak, that can be easily cleaned by sweeping or dry scrubbing, and that will dry quickly when washed; so closely fitting that neither water nor dirt can go down through it, nor any vapours or emanations rise up through it.

It is a question whether the ordinary way of making ceilings has anything to recommend it, namely, the making of a ceiling of lath and plaster below the floor of an upper room. The only advantage seems to be the deadening of sound. For reasons of health it would be much better if rooms were made like ships' decks, with nothing but the floor, well-caulked and close-fitting, between them. Under any circumstances, some ventilation under the floor is necessary. In hot countries ceilings are dispensed with, in order that the beams may be watched for fear of the attacks of white ants, and there seems no reason why the same plan should not be adopted everywhere for the sake of health. It would be perfectly easy to make them sufficiently ornamental to please the most fastidious tastes, whilst the disagreeables arising from noise would not be much greater than are met with at present in the flimsily-constructed houses which the "jerry" building of the present day inflicts upon us.

d. The Arrangements of the Parts of the House.—When we have to consider small cottages there is seldom much choice to be made in this matter. It may, however, be pointed out that no privies, pig-sties, middens, or the like, should abut on to or form part of the building itself. Neither ought dwellings to be built back to back. Each room ought to be so placed as to get light and air directly from the outside; and if there be any lobby or passage, it also should have light and air from without. Rooms or closets with borrowed lights, and without direct communication with the outer air, ought not to be used as sleeping-rooms. It is also undesirable to use the kitchen, or room where food is prepared and kept, as a sleeping-room.

In dealing with houses of a better class, there are several points which call for notice. One of the most frequent errors is the position of the water-closet, which is often close to the bed-rooms, and not in the least separated from them. Sometimes it opens through a bed-room, and sometimes it has no communication with the outer air, and is ventilated into the lobby or hall. This is an important error. The closet ought to be cut off from the rest of the house by a ventilated lobby, as will be described further on. The kitchen, larder, &c., ought to be on the coolest side of the house, the north side, if there are no other reasons against it. It has been suggested that the kitchen should be at the top of the house, so as to allow all smell and vapour to rise into the air instead of into the house. In theory this is a good plan, but there are difficulties attending it in practice which would probably prevent its general adoption.

In the order in which the causes of unhealthiness were given in Chapter I., the next to be considered would be the *conservancy* or disposal of excreta and refuse. This we shall take up in the next chapter.

CHAPTER IV.

CONSERVANCY, OR THE REMOVAL OF EXCRETA AND REFUSE.

THE word *excreta* is used chiefly to express the refuse or used-up matter that passes out from the bowels of men and animals; it generally also includes the urine, and the two are spoken of respectively as the solid and liquid excreta. As the word, however, means anything got rid of or removed, it properly applies to all the products of the changes that go on in our bodies, and ought to include the air breathed out through the lungs and the moisture and vapours given out through the skin. Now, although the great problems of health, and even of life, are connected with the way in which our waste products are to be got rid of, a convenient division is made, so that the question of *conservancy* deals with the solid and liquid excreta, and the question of *ventilation* with the lighter or gaseous (or gas-like) excreta, which pass out through the lungs and skin. Our body is a great factory, in which chemical and other operations are continually going on; we take in the crude material for manufacture, as well as the fuel required, in the forms of food, drink, and air. A perpetual making of new tissue (such as flesh (or muscle), nerve, skin, blood-vessel, &c.) is carried on; worn-out tissue is cast out, and fuel is continually being burnt all through the body to give strength and energy to enable us to do what is required of us. Now, just as in every factory there must be a drain to carry off dirty water, a dust-heap for ashes and refuse matters, and a chimney to carry away smoke and gases, so has our body the kidneys to remove water, the bowels to carry off the refuse solids, and the lungs to act as the great chimney and (assisted by the skin) to carry off all smoke and gases. Again, just as in a factory, work would soon be impossible unless all the waste substances were quickly and regularly removed, so in the case of our bodies, life becomes first difficult and at last impossible, if we allow our waste matters to remain in or around our habitations. This would seem at first so clear as to require no special argument to support it, but unfortunately it is the point most frequently neglected, either because of the ignorance, the laziness, or the avarice of mankind. Ignorance must be pardoned where no opportunity of knowledge has existed, but laziness and avarice are inexcusable in such a matter, when once the case is fairly put before people. Let it be borne in mind that at least one-third of the deaths, and a proportionate amount of the sickness of this country are due to what are called *preventable diseases*, that is, diseases that arise from causes which reasonable care on our part might have prevented, and let it be further remembered that *all* of those diseases are connected in one way or other with neglect in dealing with the waste products of our bodies, and the immense importance of the question will at once be seen. The average death-rate in the United Kingdom is about 22 per 1,000 every year, and if we assume the population to be about 34 millions, we have no less than three-quarters of a millions deaths in each year. We have no positive means of knowing the amount of sickness, but we may calculate it roughly. If we allow only twenty cases of sickness to each death, this would give nearly one-half the population ill at least once during the year; but this is a very unusual mortality, one death in twenty sick, or 5 per cent. If we put it at thirty sick to each death, then two-thirds of the population must have been sick at least once in the year. Suppose we take this number we shall have 22½ millions of persons sick every year. That this is not too great may be understood from the fact that in the army, where the proportions of death to sickness are accurately known, the numbers are 1 to 83. At this rate the cases of sickness in the United Kingdom would be 62¼ millions, or every person in the country would have been sick once, and nearly all twice in the year. Now, it is reckoned that of the 22 persons who die out of every 1,000 living, at least *seven* need not do so if the laws of health are properly attended to, so that nearly a quarter of a million deaths might be saved every year. In the same way, at least seven million cases of sickness might be prevented, taking the lowest possible estimate. The length of time a man is sick in the army is known to be nearly eighteen days; but if we put it for the country in general at only ten days, we have seventy millions of days lost that might have been saved; or, to put it in another way, at least a million and a third of people are always sick in this country.

If we take it that the half of these are children, who are not doing useful work, there still remain about 670,000 persons whose work is lost to the country. Estimating the value of each person's work at only £30 a year (less than 12s. a week), we find the loss to be £20,000,000 sterling per annum, equal to an income-tax of 10d. in the pound, or double the present rate. It is an annual sum, too, that would (at 3 per cent. compound interest) pay off our National Debt by the year 1905, and save the country about £30,000,000 of taxes every year after. We may thus see what a heavy price we pay for neglecting the laws of health, and how it is our interest, as well as our duty, to do all we can to prevent such an immense loss. And in the above calculation I have taken no account of the loss and misery caused by deaths, although that must also be large, when we remember how often people are cut off in the prime of life, and their families and those who are dependent on them left destitute, to become a burden upon the tax-payer.

Now, of the diseases which produce this great loss, about one-seventh are due to bad conservancy, and about six-sevenths to other causes. The particular diseases due to or favoured by bad conservancy are :—

- Typhoid (or Enteric) Fever.
- Diarrhœa.
- Diphtheria.
- Cholera.
- Ophthalmia (or Inflammation of the Eyes).

Besides many others, such as the Eruptive fevers, that is, small-pox, scarlet fever, and the like,—child-bed fever, and all kinds of sores and skin diseases,—all of which are made much worse when proper attention to conservancy is neglected. Typhoid fever alone kills about 20,000 persons in this country every year, and diphtheria about 4,000, whilst diarrhœa is only too common a cause of death, especially among children, about 30,000 deaths being attributed to it every year.

Let us now consider what points in the matter of conservancy ought to be attended to. We require to get rid of the following substances:—

a. Solid excreta. *b.* Liquid excreta. *c.* House slops.	These substances make up, with street drainage and waste liquids from factories, &c., what is generally included under the head of "Sewage."

d. Ashes and solid refuse of various kinds.

The plans employed for the above purposes are various, but they may be included under the heads of:—

1. Water carriage of sewage.
2. Dry systems of removal of excreta.
3. Ash-bins and dust-heaps.

Of those, the first, the water-carriage is the only plan as yet employed in most of our towns. But in some towns, and in many places in the country, dry systems have been used with great advantage. Dust-bins and ash-heaps it is hardly possible to get rid of entirely, under any circumstances.

In towns there is generally, at least in large towns, a regular system of sewers, which carry off the sewage from the houses. It is then the duty of the municipal authorities to dispose of that afterwards, so that it does not come within the scope of the householder himself. In some towns in this country, and in a great many abroad, the sewage is conveyed into large holes, which are called cesspools, or dead or dumb wells. These are emptied from time to time, the process of doing so being a terrible nuisance to the community. This cesspool system is also very common,—indeed, it is the most frequent plan,—in nearly all country districts.

The dry systems, on the other hand, are either common privies, where the excreta are received into an open pit, or closets arranged on the plan of Moule or others, in which dry earth or some other powder is mixed with the excreta, so as to deodorise it before removal.

Let us first say a few words about the position of the closet in the house, and these may apply equally well whether the system be one of drainage or of cesspools.

Our object is to get rid of refuse or waste matters, and to do so in such a way that they shall not be a source of danger to us or to others. Now the way in which sewage becomes dangerous is by tainting or contaminating the air we breathe, or the water we drink, and to prevent this must be our aim. In order to prevent the air being tainted, it is plain that the closet itself ought to be in a place removed in some way from the living and sleeping-rooms. In some towns it is placed in the cellar, a very bad situation, for the tendency of the foul air is to rise through the house. In the greater number of houses, however, it is placed on the same floor, and close to bedrooms, or sitting-rooms; often its construction is an afterthought, and it is made, either by the alteration of some small cupboard, or by taking off a part of another room. It is, however, clear enough that it is hardly possible to prevent smell throughout the house under such circumstances, and the still more dangerous gases that are apt to pass up continually from ill-constructed closets. In many houses there is a constant smell of ammonia (or hartshorn), faint, perhaps, but constant, and this is a sure sign that the closet arrangements are in bad order. There is also sometimes a peculiar sweet smell, mixed with the ammonia, giving a sensation of weak smelling-salts, which is recognised as being particularly dangerous.

The proper situation for a closet is in a separate outstanding part of the house, with which it should be connected by a passage or antechamber, provided with a close-fitting door and with *cross ventilation*,—that is, a window or opening on two opposite sides, so that air may pass freely through and cut off any smell or foul gas from the house itself. The access or entrance ought to be from a lobby or passage, and never, if possible, through a living-room; still less through a bedroom. Remembering that foul gases tend to go upwards, the best place for a closet is an upper floor rather than a lower.

As to the closet itself, it ought always to have one window at least, and this should open wide; if two opposite windows can be had, so much the better. A ventilator in or near the ceiling is also desirable: either a grating or a louvre. The walls ought to be covered with glazed tile, or with plaster painted or varnished; the ceiling ought also to be painted or varnished. The floor may be of glazed tile, or, if that is objected to as being cold, it may be of well-seasoned wood, closely fitting, well caulked and varnished. The closet apparatus itself ought to be the simplest that can be obtained so long as it is effectual. Complication by no means argues perfection or efficiency. A pan that ends in a syphon, or bent tube, is generally the best form; a little water remains in the bend and prevents the return of smell to a large extent. Pans and syphons of glazed earthenware are usually to be preferred. The worst kind of closet is the old pan with a container, for the container gets dirty, and the pan often wears out and lets the water run away. Now, as this water is intended to prevent smell arising, it is plain that, if the closet-pan is empty, smell will come up. There should be a plentiful supply of water, which should be freely let on every time the closet is used; the water also should sweep quite round the pan, so as to clean every part of it.

There are now two other points of very great importance, namely, to prevent sewer-gas (or sewer-air) coming back into the house from the drain or cesspool, and to ensure a free circulation of air in the soil-pipe itself. Nothing prevents foul gases becoming dangerous so perfectly as a free supply of fresh air. This combined with a plentiful supply of water will keep the pipes clear, and prevent the sewage remaining long enough to rot or ferment (when it becomes especially dangerous), and if any dangerous gases do form, they will be so mixed and diluted with air as to be made nearly harmless.

Three things are necessary:—

1. Have no soil-pipe *inside* the house.
2. Ventilate the soil-pipe.
3. Have an *open* trap where the soil-pipe joins the street or cesspool drain.

1. *Have no Soil-pipe inside the House.*—This is a very important precaution; for the practice has too generally been to carry the soil-pipe, generally made of lead, inside the house to the point where it makes its exit to join the drain or sewer. Now, very frequently the plumber's work is badly done,—particularly where there are any bends, and the consequence is that leakage takes place, a deposit of night-soil is formed within the house, bad smells are perceived, the health of the inmates suffers, and sometimes even fatal disease occurs. To this cause have been traced outbreaks of diphtheria, sometimes in perfectly new houses, in which no expense has been spared. Pipes have often been taken under the rooms of houses to reach the outer drain, producing deposits of night-soil under the floors, the evil effects

of which are much increased by the warmth of the rooms. The only safe rule is, that the soil-pipe shall pass direct from the closet to the open air, and be carried *outside* the house altogether, even though it may have to make a long round to get to the drain. The soil-pipe may be made of glazed earthenware or of iron, but *never* of *lead*, for that is soon eaten through by the effects of the sewage. Even some kinds of water act very rapidly on lead and corrode it. In the event of there being any danger of the pipes being frozen, covering them with some non-conducting material (such as Smith's patent felt) is a good plan. But they ought never to be so concealed as not to be at once *got at* when required.

2.—*Ventilate the Soil-pipe.*—This is absolutely necessary, and the only good plan is to continue the soil-pipe upwards some distance into the air, of the same size all the way, the top being left freely open. We have thus a long upright pipe open at the top; the closet-pipe joins at the side, and at the bottom it passes into the drain. There must also be another opening below so as to secure a free current of air. The result of this arrangement will be that any sewer air coming back towards the house will go straight up the pipe into the air, rather than turn aside to press into the house through the closet.

3.—*Have an Open Trap where the Soil-pipe joins the Street or Cesspool Drain.*—This is a trap in which there is a free opening to the air between the drain and the soil-pipe, by which means any gas forced back from the drain will most likely pass into the open air; if any does still press to the soil-pipe it will most likely go straight up to the top and make its escape, without pressing into the house. There are various kinds of traps, such as Potts', Weaver's, Stiff's, Buchan's, Banner's, &c.

If we have to deal with a cesspool belonging to the house itself, more than one opening to the air ought to be made in the course of the drain that runs to it; it is also well to have a ventilating opening or shaft at the cesspool itself, through which any gas may at once pass up, and so relieve the tension in the pipes.

Cesspools.—These are bad plans of disposing of sewage. Generally speaking, they are made (in country places at least) quite porous, so as to allow the liquid portions to soak into the ground. This is wrong: they ought to be cemented tanks, periodically emptied. If there is a garden the liquid can be pumped up and used advantageously as manure,—an arrangement which also relieves tension, on gases being generated in the pit itself.

Disposal of House-slops and Waste-water.—The plan formerly adopted was simply to carry all sink-pipes, bath-room pipes, waste-water pipes, &c., directly into the drain. The consequence was that foul smells and gases came up through them, rendering the house offensive and unhealthy. The only safe plan is to take care that no pipes whatsoever join the drain, except the soil-pipe of the water-closet. All other pipes, carrying slop or waste-water, ought to deliver freely into the open air on to a grating which covers the trap that leads to the drain. By this means no gas can get back from the drain into the house. When, however, this has been neglected, it has been shown that more disease and death, of the kind connected with sewer-air, have taken place in the better sort of houses in towns than in the poorer, because the former had direct and uninterrupted communication with the drains or sewers, whereas the latter had not, seeing that they were not provided with sinks and closets. But where proper precautions have been taken these conveniences are advantageous to health.

Sink-pipes ought to be provided with a syphon which will act as a partial trap, keeping back smell that might arise from grease, &c., about the pipe itself, or from the trap below. The common bell-trap is of little use, except to prevent solid matter pressing down and choking the pipe: a common grating would really be more useful. A grease-trap is necessary to receive sink-water or bath-water: of such traps Mansergh's or Dean's are good forms. The waste-water pipes of cisterns ought also to deliver free in the open air, otherwise there is danger of the water being contaminated. Rain-water pipes ought also to flow on to a grating, and never to join the drain directly. When this has been neglected, it has been found that sewer-air has passed up them and entered rooms through windows or other openings, causing dangerous and sometimes fatal disease.

In *villages*, where there is no system of drainage, the common plan is to carry all slops into the cess-pool, along with the excreta: here the same precautions must be used with regard to the house-pipes. Sometimes the slops are thrown out round the house: this is a bad plan, as it keeps the ground damp and gives rise to unhealthiness. It is also wrong to throw slops into the ash-pit or dust-heap, as they increase the rapidity with which the refuse organic matter, such as scraps of all sorts, cabbage-stalks and the like, rot or putrify. If no cesspool is used for the excreta (as in a dry system of conservancy), and there is no system of drainage, then a special dumb well must be provided for the slops. Even in this case, however, the same precautions must be adopted with reference to the arrangements of sink-pipes, waste-pipes, &c., for they must all be *disconnected*, and discharge freely in the open air, as the only means of checking the rising of emanations into the house. Even in the absence of excreta proper, gases of an offensive and even dangerous character may form.

2. *Dry Systems of removing Excreta.*—Of these there are several, of different degrees of usefulness.

Common Privies. — These are simply receiving-holes, over which a seat is placed: they are generally allowed to accumulate an indefinite time. It is better to have them emptied at regular periods, and the material removed or used for agricultural purposes. Usually the hole goes some way below the ground-level: it is better not to have it so, but to have the bottom of the receptacle a few inches above ground-level, and only of moderate size, so that it must be emptied within a reasonable time. It is also advisable to scatter ashes, earth, or some drying material over the filth from time to time.*

Earth-closets.—But a far better plan is to use a regular earth-closet or similar contrivance. The essential principle is to receive the excreta into a pan or receiver of some kind, which contains dry earth or some other powder, a little of which is added each time the closet is used. In Moule's, or the original earth-closet, there is an ordinary metal bucket, in which earth is placed; there is also a supply of earth in a hopper, some of which is scattered into the pan when the place is used,—the mere sitting down and rising up working the hopper. It may also be arranged to work with a handle if required. The effects of dry earth in removing smell and cleaning water are well known, and as earth can be got anywhere it is the

* See the recommendations in the Model Bye-Laws of the Local Government Board.

most convenient thing. The pan is easily removed and emptied as required. The requirements are that the earth should be dry, and that slops should not be emptied into the closet. It may be a little difficult to get dry earth in wet or damp weather; but even if there be no outhouse, in which to lay up a store of it in hot weather, a sufficient quantity could always be dried in a box near the kitchen fire. As dryness is so necessary it is plain enough that slops ought not to be put down the closet.

Other closets have been designed by different makers, some of which have slight advantages over the ordinary one, such as Taylor's and Moser's. In both of these arrangements are made to separate the urine (or liquid) from the solid excreta, in the one by running it off into a drain or tank, and in the other by having a division in the pan and absorbing it with cotton waste or some such material.

Another plan, which has been found very useful in villages, is the *Goux* system. This consists in packing the bottom and sides of the pan or receiver with straw, dry horse-litter, cotton waste, or any fibrous substance that can be easily got. The excreta are received into it and the urine is at once absorbed by the lining; this prevents putrefaction until the contents are removed, to be used as manure. This separation of liquid and solid answers much the same purpose as the dry earth, and, indeed, the two may be combined with advantage.

Any of these dry methods is good with a very little care and attention; they effectually get rid of all danger from sewer or cesspool air, and also do not risk poisoning the water of wells or cisterns.

3. *Ash-bins and Dust-heaps.*—These are among the annoyances and dangers of habitations. They ought

not to be too close to the house; the model bye-laws name 6 ft. as the least distance; but further than that is desirable. The nearer they are the oftener ought they to be emptied. It would be a great advantage if all scraps and odds and ends of an organic nature were burnt, instead of being put into the ash-bin; this includes all scraps of food, whether animal or vegetable, rags, &c. If a fire could be kept going in a village (as is the case in the camp of an army), where all such refuse could be thrown, it would greatly improve the health of the place. At present, not only are those things thrown into the ash-heap, but slops are sometimes poured in too: this is dangerous; even rain favours rotting, and therefore no water ought to be willingly thrown in; on the contrary, there ought to be a little drain or gutter to carry off any water that may get in accidentally. The ashes, properly sifted to save the cinders for fuel, may also be used for a dry closet or privy, should the supply of dry earth run short, or even as an addition to it.

From neglected dust-heaps disease may be caused, and, in particular, that fatal disease, diphtheria, has to all appearance arisen in some cases from this cause.

CHAPTER V.

WATER SUPPLY.

The condition of the water supply is a highly important point in connection with the health of the inmates, for it may affect them by being either *deficient in quantity* or *bad in quality.* If deficient in quantity it prevents proper cleanliness of the person, the clothing, and the house itself; it also seriously affects the conservancy, if there be a system of drainage, even of the simplest kind,—for the water-carriage of sewage is only safe and good if the water (as one necessity) is in sufficient quantity to carry off everything effectually. If this be not the case, our drains are merely *long cesspools*, and nothing more;—the sewage will remain in them until it begins to decompose and give off foul and dangerous gases, which both offend our senses and endanger our health. If the water be bad in quality it is, of course, plain enough that health is likely to suffer, seeing that a considerable quantity is swallowed daily by every one, either as a drink or along with food. This is, perhaps, one of the reasons why children are among the first to suffer from an invasion of disease.

1. *Quantity of Water required for various Purposes.*—The quantity of water required varies with circumstances, but there are certain amounts that cannot be done without. In the first place, each person must have a certain quantity as drink every day. It is true that this may be taken in various forms, as beer, wine, tea, coffee, soup, &c., and some people say that they never drink a drop of water, meaning that they take no liquid but beer or wine; this, however, only means that they do not drink of the ordinary water-supply of the place they live in, but they still take a large quantity of water in those liquids. Another considerable source of water is found in the food we eat. Every article of food, even the driest-looking, contains a proportion of water; sometimes the amount is very great. Thus, a pound of ordinary butcher's meat contains about three-quarters of a pound of water; a pound of potatoes about the same; a pound of cabbage even more; a pound of bread about two-

fifths of a pound of water; and even flour about one-eighth. Even the very driest-looking articles, such as lump sugar,* arrowroot, corn-flour, tapioca, &c., contain some water, although the quantity is very small in some of them. Pure well-made butter contains very little water, but there is generally some to be found. In addition to this water, which is called *constituent* water, or water which is in the food in its ordinary state, a good deal more is added in cooking, a part of the art of which consists in softening and swelling out the food by making it take water up by the aid of heat. We find by inquiry that the quantity of water used for the body,—that is, swallowed,—bears a certain proportion to the weight,—very nearly *half-an-ounce*, or a tablespoonful to every *pound weight*. Thus, if a man weighs 150 lb., he will require about 75 ounces, or nearly half-a-gallon of water in the twenty-four hours; or, if we state the weight in stones, it will be nearly a *gill and a half* for every stone weight;—thus, a man of 12-stone weight will require about 17 gills, or four pints and a quarter, in the twenty-four hours. Of course, there are differences with different persons, according to age, sex, occupation, or personal peculiarity. Children drink a great deal more than old people, and people who work hard a great deal more than those who sit quiet; more is also drunk in hot weather than in cold. Of this amount of water, about one-third is taken with the so-called solid food, and the remainder (about two to two and a half pints on an average) as drink, either in the form of water itself, or tea, coffee, wine,

* Sugar and starch consist of carbon and the elements of water, but the water above referred to is what may be removed by the simple process of *drying*, without breaking up or decomposing the substance.

beer, spirits, or in soup, milk, or other liquid kinds of food.*

A good deal of water is also used in cooking, and still more in the washing of utensils.

Water is also required for personal washing, including baths, when these are taken, as they ought to be, for health and cleanliness.

The washing of clothing also requires a good deal, as well as the general cleansing of the house.

In addition to the above requirements, a good deal of water is also necessary where water-closets are in use, and, still more, if there be a regular system of drainage. Taking the different quantities necessary, we find, from experimental inquiry, that the following is a fair daily average for each person, including women and children:—

Drinking and cooking.........	about	1	gallon
Personal washing (not including a bath)	„	2	„
Share of utensil and house-washing	„	3	„
Share of clothes-washing ...	„	3	„
Total		9	gallons

The above does not include any allowance for baths; but no household can be clean without baths, and every one ought, if it is at all possible, to take a sponge-bath daily. This would take about 2½ to 3 gallons. Therefore, the total necessary would be 12 gallons, as the least that ought to be used per head, in a fairly

* Milk contains about 87 parts of water in 100 of milk; beer about 92; wine, such as claret, about 90, sherry about 80; spirits usually about 50. Soups and liquid foods of course vary with the mode of preparing them.

cleanly household. In a large number of cases the real amount used is very much less; but in those cases cleanliness is by no means the rule.

The above amount, 12 gallons, may, therefore, be looked upon as the least daily quantity that ought to be allowed for each person, where water-closets are not in use; as, for instance, where earth-closets are used. If, however, water-closets are employed, we must add, at least, 5 gallons for them, remembering that unless a good supply of water is allowed for them they cannot be kept in good order. Adding this to the 12 gallons before reckoned, we have about 17 gallons for each person every day as necessary to keep a household clean and healthy.*

When animals have to be provided for an additional quantity must be allowed; as, for instance, where horses are kept. A horse will drink from 6 to 10 gallons a day, and if to this we add the quantity for washing the animal and the cart or carriage he draws, and for cleaning his stable, about 16 gallons daily for each horse ought to be reckoned. A pony, donkey, or mule would, of course, require somewhat less, not more than about one-half to two-thirds of the amount.

When a regular system of drainage exists, as in a town, and particularly where there are manufactures, a much larger amount is necessary; but as this does not specially alter the amount required for the *house* itself, it is unnecessary to do more than refer to it. Where there are regular water-works, the supply usually amounts to from 30 to 60 gallons per head each day, only a few towns, however, reaching or even approaching the higher number.

We may, therefore, lay down the general rule, that

* In the army 15 gallons per head are allowed, but this is decidedly too little for all requirements.

where water-closets are in use, not less than 17 gallons ought to be supplied; and where earth-closets are used, not less than 12 gallons, in each case daily and for each person.

When there is sickness in a house an additional quantity of water is always required.

2. *Source of Water.*—Water may be obtained from various sources, which vary in quality and quantity.

In a town the supply is usually arranged for by some public body, either a water-company or the municipality; and, therefore, the householder has no choice in the matter. In the country, however, where no general supply is provided, a choice may have to be made, and under any circumstances the question of the source of the water is one that much more specially concerns the consumer.

The chief sources of water are the following:—

1. Rain.
2. Wells.
3. Springs.
4. Rivers or streams.
   Lakes or ponds.
6. Collected surface-water.

These differ very considerably in the constancy of the supply, and in the quality of the water yielded.

Rain-water.—In this country, where there is tolerably regular rain-fall, a good deal of water may be got in this way, and if there be sufficient means of storing it, a supply may be obtained for a good long time. It depends, however, a great deal upon the size of the collecting surface in relation to the number of people who are to use it. The usual collecting surface is the roof of the house, if the roof be of slate.

Tile is less desirable, and thatch, of course, quite inapplicable. If we are to depend upon rain-water, we must know how much we are likely to get; and in order to do this, we ought to know the size of the receiving-surface and the amount of rain-fall. To do this we must measure the size of the house, by simply measuring the length and breadth, and multiplying the two numbers together. Thus, a cottage 20 ft. long by 10 ft. broad (or deep), gives us $20 \times 10 = 200$ square feet. An inch of rain falling upon a square foot gives rather more than half-a-gallon, or an inch upon 200 square feet would give about 106 gallons. Now the average rainfall in this country is about 30 inches, so that this would yield 3,180 gallons, provided all was collected, and none lost. But we know that this is practically impossible, and that if we got even 1,000 gallons we should be fortunate. We must then divide this amount by 12, the quantity necessary for one person in a day, and 1,000 divided by 12 gives us about 83, or this amount of water would be enough for one person for about 12 weeks, or for two persons for about six weeks. This, of course, would be a very small quantity, but the truth is that rain-water is seldom depended upon as the sole supply. It is, however, very useful for cooking and washing purposes, as it is both more useful and more economical: it is also good for drinking, if cleanly collected and stored, although some persons dislike it as being too soft. Under any circumstances it is a useful source of water, which ought not to be neglected. It differs from most other waters in containing very little hardness and very little salt. On account of its softness it admits of cooking, especially of vegetables, being more easily done; and it makes much better tea, with much less waste. As for washing, the saving of soap is considerable; every degree of hardness wastes 8 or 9 grains weight of soap, and when this comes to be multiplied by days and weeks, it quickly mounts up to a serious sum. A degree of hardness means that one gallon of water contains one grain of carbonate of lime (common chalk); there are 7,000 grains in a pound weight; therefore, 7,000 gallons of water of one degree of hardness would contain 1 lb. of carbonate of lime, and that would waste 8½ lbs. of soap. But nearly all waters, except rain-water, are much harder than this, their degrees reaching 10, 15, or 20, so that if we were dealing with a water of 20 degrees of hardness, our 7,000 gallons would waste 170 lbs. of soap. This quantity of water would easily be used in a year by a family of say seven persons, if we include the washing of clothes, so that, with soap at only 3d. a pound, we have a pure loss of 43s. per annum in this item alone, or an amount equal to the income-tax upon £100. There is also to be added loss caused in cooking, making tea, &c. For persons who get their living by washing, the importance of using soft water is very obvious.

Rain-water, however, is apt to be impure from various causes. The collecting surface, usually a house-top, may be dirty, and soot, dust, and the different things that float in the air, may find their way into it. Near the sea there is often a great deal of salt found, caused by the sea-spray being carried up into the air. Other impurities are caused by want of care in keeping the cistern, tank, or water-butt clean; this should be carefully seen to. If there is much impurity that does not settle down in standing, a filter of some kind must be used (see page 60). A very serious danger to which rain-water is exposed is poisoning by *lead*, from the roofs or gutters of houses;

it has a very marked action on lead, and easily dissolves enough of it to be poisonous. If, therefore, there be lead on the roof it is safer to use the rain-water for washing only, but not for either drinking or cooking.

Wells.—This is probably the most common source of water in country districts. There are two kinds of wells,—deep wells and surface wells,—and these differ very much in character. The water of deep wells is generally pure and good; such a supply often furnishes a large part of the water delivered by water companies in towns. Surface-wells, on the other hand, often yield very impure water. A shallow or surface-well is one that does not go further down than 15 ft. to 20 ft. or thereabouts, and particularly a well that goes through only the upper layer (or *stratum*) of the ground. Thus, if we have a soil of gravel or sand for about 20 ft. down, and if we dig a well 15 ft. or 16 ft. deep, the water that we get will obviously be the surface water that soaks down; for a well drains the ground to the distance of its depth in every direction. If, then, we sink our well in the floor of our kitchen, or closet of the cottage, we get the water which has been poured over the surface of the ground all round the house, whether it be rain, slops, sewage, or anything else. It is true that, in passing through the ground, it is partially cleaned and purified, but seldom sufficiently so as to be really good and wholesome. Where cesspools are used the danger is evidently very great, especially if they be made of open brickwork to allow the liquid sewage to pass out into the soil. A good well, then, ought to be a deep one, 30 ft. deep or more if possible; the upper part ought to be carefully *steined*, that is, the sides built up with masonry, and it ought to pass quite through the upper *stratum* of ground, into or through the next. The object of these precautions is to prevent, as far as possible, the immediate surface-water getting into the well, and to get the water that comes down from a distance away from the house itself. We thus avoid the direct impurities of our own surroundings, and, if the water we get does soak down from a more or less impure source, it is at least compelled to pass through a much greater depth of soil, with the chance of being better filtered. Above all, there ought to be no drain or cesspool within a considerable distance of the well. I have frequently seen the drinking-well so close to the cesspool that the passage of filth from the latter to the former must have been constant; sometimes in heavy rain the overflow from the cesspool could be seen pouring down into the well. I have known disinfectants poured down a closet, and the smell of them detected in the drinking-water within an hour or so. All this is very disgusting, to say the least, but it is also very dangerous, and a common cause of disease and death. The sanitary authorities have power to close surface-wells, which are found to be impure, and this power ought to be frequently exercised in the interests of the people themselves.

Springs.—These are generally good sources of water, provided that they are not what are called *mineral* springs, that is, containing a large quantity of salts. Springs are simply places where water presses up that comes from some considerable distance. Probably on that account the water is generally pure and good, because it has passed through a great distance of soil, and has thus been freed to a large extent of any impurities it may have contained. If we are to depend upon a spring for our supply, we ought to see that it yields a sufficient quantity, both in wet and in dry weather; and this can be easily ascertained by simply measuring the yield and calculating accordingly.

Rivers or Streams.—These are good sources of water, although sometimes hard when running through certain soils, such as those of chalk districts. Unfortunately, however, this excellent natural supply has been rendered worse than useless by man's own acts, advantage being taken of the running water to make it a channel for carrying away all sorts of filth The Rivers Pollutions Prevention Act will do something to lessen the evil; but it still exists in many places. It is, of course, very dangerous to use water from rivers into which sewage is poured, unless at a very great distance from the place of pollution. The same may be said with reference to the waste water of factories and the like. If, however, filth is not poured by man into streams, running water is one of the best kinds of water for all purposes; for it is not necessarily too hard, and is generally well aërated and pleasant to drink.

Lakes or Ponds.—These are also good sources of water, unless contaminated by man. They seldom contain much organic matter, except of a vegetable nature, which is comparatively harmless. But if impurities of an animal kind, such as sewage, are allowed to pass in, they become dangerous like other waters. It is also unadvisable to draw drinking water from a place where cattle or other animals are taken to wash or drink.

Collected Surface Water.—The value of such water varies greatly. If it is from cultivated land, or the neighbourhood of habitations, or from marshes, it is pretty certain to be dangerously impure. On the other hand, rain-water collected in open moors, sandy plains, and even from peat-bogs, is generally fairly good, especially if the place of collection be an upland.

The Rivers Pollutions Commissioners classify the different kinds of water in their order of wholesomeness:—

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

It will be observed that this table corresponds with the remarks already made about the different kinds of water.

In towns the inhabitants have generally to content themselves with the supply furnished by the water-companies, trusting to the authorities to see to its goodness and purity. On the whole, it is safer to do this than to use the water of wells, of which some are still to be met with in towns. In some cases, however, if the town supply is very hard, it may be useful to collect the rain-water for washing purposes, but not for drinking or cooking. Stored rain-water, containing such impurities as it would collect in towns, is apt to become bad, so as to be disagreeable and dangerous.

3. *Mode of Delivery of the Water.*—In towns the water is laid on in pipes and delivered, either to each house, or in the smaller class of houses, to some common tap for several houses. It ought to be laid on to each house separately, and to each floor of every house. Experience shows that if difficulties are put in the way of getting water, cleanliness will be neglected, and the health of both the individual and the community will suffer.

There are two ways of delivering water to houses, called respectively the *constant* and the *intermittent* plans. On the *constant* plan, the water is always *on* in the pipes, at a good pressure, so that it can be got at any time. On the *intermittent* plan, the water is only turned on at certain times of the day, so as to fill the cisterns in the house. There can be no doubt that the constant plan is the better of the two, provided that it is *really constant*, which is not always the case; if it is not really constant, it has all the disadvantages of the other, without the arrangements for storing water. The reasons for preferring the constant plan are these:—

1. There is no likelihood of running short of water; with the intermittent plan this may occur, if the cisterns are not sufficient for the number of the inmates.
2. There is no danger of the water becoming impure from causes in the house itself. With cisterns, on the other hand, this danger has always to be guarded against.

The objections to the constant supply are made on the part of the companies, and they are as follows:—

1. There is greater waste of water, either by carelessness of the inmates, or by accident to pipes.
2. The fittings are more expensive, and are liable to be stolen.

Neither of these objections can be weighed against the great advantages to the consumer, and with proper precautions both can be guarded against. A good many towns are already supplied on this system, and it will no doubt be, in the long run, the rule in all.

Of the dangers and inconveniences of the intermittent supply we shall speak presently.

In the country the water is seldom laid on to houses, having either to be carried some distance, or pumped or drawn from a well on the premises. It is a great disadvantage to have to carry water any distance; it takes up time and labour, and is a direct encouragement to neglect of personal and household cleanliness.

When wells are employed, it is very much better to have a pump than a draw-well, for the following reasons:—

1. The draw-well must be opened every time water is drawn; it may be forgotten to be closed again, hence it becomes a source of danger. Children may fall in and be drowned, as has happened in cases within my own knowledge. Animals, such as pigs, cats, dogs, &c., may get in, and their decomposing bodies poison the water. This I have known occur in several instances. Various kinds of filth may find their way in.
2. The use of the bucket disturbs the water, and stirs up the sediment, especially if it be a well with no great depth of water. This is decidedly objectionable.
3. The drawing of water costs more time and labour, and if the well be in the house it generally causes the floor about the mouth of the well to be damp.

A pump fixed over the well gets rid of a great part of these inconveniences; there is little risk of impurities getting directly into the well; the pipe that sucks up the water does not stir up the mud at the bottom; and, if a force-pump be used, the water may be carried to any part of the building.*

4. *Causes of Impurity of Water.*—We have already spoken of the impurities which may arise in water at its source, that is, before it reaches the consumer. But there are many impurities that it may acquire in the habitation itself, and these are, indeed, the most important in a large number of instances.

Pure water consists of two gases, hydrogen and oxygen, in combination, but this in its absolute purity is never met with. Even rain-water contains many substances besides water itself. All ordinary water contains common salt, carbonate of lime (chalk), and a few other salts, in varying quantities; it contains, besides, *organic* matter, either animal or vegetable, which is always ready to decompose; this is the really dangerous substance. There are, besides, substances which result from the decomposition of organic matter, such as nitric acid and ammonia. There are also gases, such as carbonic acid (the choke-damp of miners), the gas that causes the effervescence of soda-water or ginger-beer, and common air. Unless water is really brackish, or very bad, we ought to taste nothing except the gases, for the other substances are in much too small quantity to be perceived; they are still, however, in sufficient quantity to do a great deal of harm. The dangers to water in houses arise from two impurities, metallic salts and organic matter. These are introduced for the most part in the pipes and cisterns, by which it is carried, and in which it is stored.

* Another plan for isolated houses is the use of a hydraulic ram in a stream of water, but of course this is an expensive plan,—too expensive for general use for single houses. It is a question, however, whether it might not be put in practice for hamlets or small villages.

Metallic Poisons.—The chief poison under this head is *lead*. Certain waters act very strongly on lead, rain-water particularly, soft waters generally, and waters containing nitric acid, which is always found in wells in the neighbourhood of cesspools. It is an extremely dangerous poison, one-tenth of a grain in a gallon (or one part in 700,000!) being enough to produce poisonous symptoms. No tanks or cisterns ought to be of lead or be soldered with it. Pipes are less important, unless the water is to be long in contact with them; but it is better to have no pipe of lead, except the short delivery-pipe at the tap. Water companies generally insist on the house-pipes being of lead, to prevent waste in case of bursting, because a leaden pipe can be easily closed up with a few blows of a hammer. It is also dangerous in some cases to have the supply-pipe of a pump made of lead; the best substitute is block-tin, but it is also the dearest. Haines' tin-lined lead pipe is good and cheap for house-pipes, but will not do for the supply-pipe of a pump. Tanks and cisterns ought to be of slate, or stone, or earthenware, widening out from bottom to top if exposed to any chance of freezing; this prevents their bursting. All cisterns should be kept carefully clean, and ought to be examined from time to time; they ought to be properly covered and not exposed to impurities of any kind. Their overflow pipes ought to pass outside and deliver freely in the open air, on to a trapped gully or grating. They ought never to have any connection with a water-closet; that is, the same cistern ought never to supply a closet and also supply the drinking water. Each closet ought to have its own cistern or service-box. Neglect of this precaution has been a frequent cause of disease, and it is impossible to feel free from danger if this is not properly carried out.

Impurities may also be derived from the vessels in which water is collected or kept. If vessels are used, both for carrying slops and fetching drinking-water, there is obvious certainty of contamination. This is a disgusting idea, but it is often done, when vessels are few in the houses of the poor. Earthenware vessels, if kept clean, are not likely to contaminate water; but metal vessels sometimes yield something to it. Thus, iron vessels, unless glazed or otherwise protected, are readily acted upon by water, which becomes red and unpleasant to the eye as well as to the taste. Such water is also bad for cooking and washing, as it does not prepare the food properly, converts tea into ink and ironmoulds the clothes. The so-called *galvanized* iron vessels are merely iron, thinly coated with zinc; they resist action for some time with ordinary good waters, but with waters in which organic matter has already decomposed, and which consequently contain some nitric acid, a rapid chemical action takes place, the zinc is dissolved, and is sometimes present in sufficient quantity to give a bad taste to the water and have poisonous effects.

Disease-Poisons.—The *diseases* which we have to dread, as being likely to be conveyed through, or favoured by impure water, are *diarrhœa, typhoid fever, cholera, dysentery,* and some kinds of *worms.* *Ague* may also be conveyed by marsh-water, and there are some other diseases of less frequency which, however, I need not refer to further. Of the diseases I have just mentioned, cholera only comes occasionally, and dysentery is now happily rare in this country; but diarrhœa is only too frequent, especially among children, whilst typhoid-fever yearly demands its thousands. This disease appears to be capable of being conveyed both by air and water, and it has been said that "the rich take it through air, the poor take it through water." The meaning of this is, that the poor have generally had less pure and less plentiful supplies of water than the rich, whilst on the other hand the presence of water-closets, slop-sinks, and the like, in the houses of the rich, have led, through defects of drainage, to the introduction of poisonous sewer-air into their houses: the absence of those conveniences has so far spared the poor from receiving the poison in that particular way. But it may be clearly seen from what has gone before that there is no reason why the water-supply for the poor should be bad, if precautions are properly taken; nor is it at all necessary that the existence of sinks and water-closets should be a means of dealing out poison, instead of a convenience and a blessing.

Purification of Water.—When a public water-supply is provided it is supposed that the water shall be furnished pure and fit for use; but unfortunately this is not always the case. The reports on the metropolitan water-supply, which are made periodically by Professor Frankland and Colonel Bolton, show that the water is very often dirty and quite unfit for use. This proves that the arrangements for purifying are not complete enough, especially when heavy rain-falls and storm-waters wash down mud and refuse into the streams or collecting-reservoirs. It is, therefore, necessary for the inmate to take care of himself by purifying the water after he receives it.

When rain or well-water is used, it has very generally to be purified before use.

What, then, are the qualities of good drinking-water, and how are they to be obtained?

It would, of course, be out of place here to go far into the chemical and microscopical characters of water, but there are certain physical characters,—that is, those conditions that can be easily detected by the ordinary senses,—that are useful guides. Thus, by looking at the *colour*, *clearness*, *taste*, *smell*, &c., we can obtain information of considerable value, although these are not quite sufficient to tell us *all* about a water.

Colour.—A good water ought to be as nearly colourless as possible. When a large quantity of it is looked at, in a glass or white vessel, it has a bluish tint. If this be its appearance it will rarely contain any dangerous impurity.

If the colour is *green*, it shows the presence of vegetable matter, which is not necessarily dangerous.

If the colour is *yellow*, it generally shows the presence of animal matter, often sewage.

There are, however, some exceptions. Thus: water from peaty soils is often very yellow, but it contains vegetable matter only, and is usually quite wholesome. A yellow colour is also sometimes caused by *iron* being present. Now this, although unpleasant and disadvantageous for washing, is not unhealthy, for we seldom find a water contain much organic matter if there is much iron present.

To sum up the question of colour:—

Colourless or *bluish* waters are the best.

Greenish waters come next.

Yellow waters are the worst, and ought to be avoided, unless we *know* the colour to be due to *peat* or *iron*.

Clearness.—No water can be called a first-class water that is not clear and free from sediment. If a water is clear and bright, the chances are much in favour of its being pure also; at the same time this is not always the case. There is strong reason to believe that the most dangerous substances in water are not those which are *dissolved*, but those which are *suspended*. Thus, if we put sugar and chalk into water, the sugar will *dissolve* without interfering with the clearness of the water, but the chalk will not *dissolve*, but remain *suspended* in the water, and cause it to appear white and milky. Now a great many impurities that find their way into water do not dissolve, but remain suspended, such as particles of excreta, decaying animal and vegetable matter, eggs of worms, and other small creatures, &c. These interfere, more or less, with the clearness of the water. Of course water is also made thick and troubled by coarser matters, such as sand and mud after rain and the like; these subside by the water being allowed to stand; but this often takes a long time.

Taste.—Water should have a pleasant, sparkling taste, due to the gases dissolved in it, that is, the carbonic acid gas and common air chiefly. Water which does not contain these in any great quantity, such as rain-water, is flat and tasteless. It is a common error to think that the taste of water is due to the salts or solid matter dissolved in it; this is quite wrong; so soon as we begin to taste the salts or solid matter, it is time to give up using the water. A bright or sparkling taste is not always a proof that the water is pure, for sometimes this may come from gases which are the result of rotting or putrefaction, but generally speaking it may be regarded as a good sign.

Smell.—Water ought to have no special smell. When good water is freshly drawn it often has an odour, not easily described, but like the smell of fresh pure air. This is the only kind of smell there ought to be; anything else is a sign of impurity.

Touch.—Water ought to be soft to the touch, and should dissolve soap easily. This shows that there are not too many hard salts in it.

We may sum up the qualities of good drinking-water thus:—

It ought to be as nearly colourless as possible.

It ought to be clear, bright, and without sediment. (Printed matter should be legible through at least 18 inches of it).

It ought to have a pleasant, sparkling taste.

It ought to have no smell.

It ought to be soft to the touch, and dissolve soap easily.

How are we to obtain these qualities if the water itself does not originally possess them?

Various plans have been employed, but the most practicable are the following:—

1. Allowing the sediment to settle; this may be helped by adding certain substances to the water.
2. Boiling the water to destroy the activity of organic matters.
3. Adding some chemical substances.
4. Filtering.

In order to help the sediment to settle, the best substance to add is a pinch of common alum; this clears water very quickly, but, of course, too much must not be used or it will make the water hard and unwholesome.

Boiling is a very useful plan, if we have doubts about the purity of the water; it effectually destroys the activity of most of the organic matter, and probably destroys any eggs of worms, &c. If the water is hard, especially if it is chalk hardness, a good deal of the hardness is got rid of by boiling, as the chalk becomes insoluble and settles; in doing so it carries with it a great deal of the organic matter.

Some chemical substances may be occasionally added to destroy organic matter; but it is, of course, clear that only those that are tasteless and harmless must be used. Among these the most useful is Condy's fluid, a few drops of which may be added, without danger, so as to destroy organic matter. It should be added gradually, until the water is pink for a little time. One objection is the yellow colour that follows; this can be partially got rid of by means of a pinch of alum.

Filtration.—The use of filters is now very general; but a good many wrong notions are common on the subject. Many people think they have nothing to do but to buy a filter, and use it for an indefinite period, without any further attention. This is quite wrong. Whatever material may be used, it becomes useless after a time, and requires cleansing and renewal. On this account it is strongly recommended that no filter should be got that does not allow the filtering substance to be taken out and cleaned or renewed. The substances most in use are *animal charcoal*, either in loose fragments, or in solid blocks, specially prepared; *spongy iron, sand and gravel, porous blocks of stone*, &c. For large filter-beds, such as are used by water-companies, sand and gravel are chiefly employed, and even for house use a sand-filter stops suspended matter to some extent. Ordinary filters, however, are generally filled with animal charcoal, with the exception of the spongy iron one. Both these substances act powerfully upon organic matter, the charcoal being rather the more rapid of the two. Their power, however, is limited, and the filtering material must be renewed, or, in the case of the charcoal, reburned, from time to time. This ought to be done every few months at least; oftener, if the water that has passed through has been very dirty. If a filter be in use which cannot be opened up, it may be cleaned to some extent by turning it upside down and pouring clean water through it the reverse way, then some weak Condy's fluid, followed by some weak sulphuric acid; then finally washing well with clean water. A simple form of filter consists in putting some animal charcoal, over some fine gravel, into a common flower-pot. Instead of animal charcoal, common earth, heated *red-hot* in a shovel, and allowed to cool, would answer very well.

In ordinary filters there is usually a sponge at the opening where the water pours in; this is to arrest suspended matter and prevent the filter getting clogged. Unfortunately it is often allowed to get so dirty as to become a source of danger; it ought to be carefully looked to and cleaned, or renewed frequently. If this is not done, it would be better to do without it altogether, and get rid of the coarser suspended matter by mere settling or standing, before pouring into the filter.

Most common filters are faulty on account of the thickness of the layer of filtering material being quite insufficient for the work it has to do.

Water ought not to be left long in contact with animal charcoal; it ought also to be used at once after filtration, and not stored. Apparently animal charcoal yields something (phosphates?) to water which favours the growth of very small organisms, which might prove injurious. On this account, too, the practice of placing a filter *in* a cistern is one that cannot be recommended.

A new material has recently made its appearance in the market, called *mineralized carbon.* This seems to combine excellent filtering powers with a freedom from any injurious effect on the water.

CHAPTER VI.

AIR.

The air that we breathe, although so completely invisible to us, is of all things the most important for existence; we are more at its mercy than at that of any other influence that could be named. If we think the food offered to us unsound, we can abstain from it, and we may do this for some considerable time, at personal inconvenience it is true, but still without actually endangering life. In the same way, but to a much more limited degree, can we stop using water if we have any suspicion of its wholesomeness and purity. But, in the case of air, we have literally no choice; there is no time for decision given to us; we must breathe the air around, poisonous though it be, or we shall most certainly die. Such being the case, we should expect that the most particular care would be taken to get and keep the air we breathe as pure as possible,—but, curiously enough, this is the very last point that most people think of. Many who are particular, and even *nice* about their food, and who take some trouble to have pure water to drink, do not seem to think it necessary to pay the smallest attention to the purity of the air they breathe. This, perhaps, arises from several causes; the air is not to be seen and handled like other things, and, therefore, its importance is overlooked; breathing is so absolutely a part of our natural existence that it goes on without our being aware of it, until we are in actual danger of choking; the attention to the purity of air requires to be so constant and untiring that people give it up out of weariness. These are some of the probable causes of the neglect of this most important subject. Others are likely connected with the difficulties of warming in our cold and changeable climate, and with the fear of incurring expense that would press hard upon limited means. Some of these reasons are founded on ignorance, others on mistakes,—many on sheer indolence.

It may be well to say a few words about the composition of air, and the impurities to which it is liable.

Atmospheric air consists chiefly of two gases, in the following proportions:—

Oxygen	about	21 parts.
Nitrogen	„	79 parts.
Total......		100 parts.

The quantities are really very slightly less, because there are other substances too, but these are in such small quantities that they amount to very little apparently.

The other substances are:—

Carbonic acid......	0·04 ($\frac{4}{100}$) in 100 parts.
Watery vapour ...	varies with the temperature of the air.
Ammonia	a mere trace.
Ozone	a variable quantity.
Organic and suspended matter	Ditto ditto.

These substances are all found in pure fresh air, taken from places where impurity is not likely to reach,—such as mountain tops, open plains, and the like. But in towns, or anywhere where men or animals congregate, a great number of impurities are found, which are more or less dangerous to those who breathe the air.

The uses of some of these substances are well known, although the exact use of all is not quite certain.

Oxygen is absolutely necessary for the existence of all organic beings, whether animal or vegetable, for if they are deprived of it, or even if the supply is very materially lessened, they die. It is also necessary for every kind of combustion, such as the burning of coal, wood, gas, &c., and it is necessary for every kind of light, except the electric light.

Nitrogen appears to act to a large extent as a substance for diluting or weakening the strength of the oxygen; for this latter gas would be too strong if breathed alone, and would soon kill us. Nitrogen acts like the water used to mix with wine or spirits, when these are too strong to be drunk alone. It is possible it may have other uses too, but on that point we as yet know very little.

Carbonic acid is the substance produced when *carbon*, which forms the greater part of coal, is burnt: the carbon unites with oxygen; their union produces heat and light, and the carbonic acid is given off. It is also given off from the bodies of men and animals, as we shall see presently. Carbonic acid is especially useful to plants, as it is from this gas that they get the greater part of their substance.

Ammonia is a substance that comes from the decomposition of organic substances; it is the substance which is known as spirit of hartshorn; it gives the peculiar smell to rotten fish, decomposing urine, &c. It is probably absorbed by plants, and helps their growth, and it is the substance which forms the most valuable part of most manures.

Watery Vapour is always present in the air more or less. Most people connect the idea of watery vapour with that of steam; but steam is simply the vapour of water, given off at a high temperature and condensing or becoming visible as soon as it cools in the smallest degree. But water is always giving off vapour, even when it is cold; for, if we leave a saucer of water exposed to the air, it dries up sooner or later, and this has taken place by the water going slowly away in the form of vapour. As the temperature (or heat) of the air rises, it can take up a much greater quantity of vapour; therefore water dries up much quicker in warm air than in cold. But at every degree of temperature there is a certain amount of vapour which can be taken up and no more; so soon as more vapour than this is present it begins to condense into dew or mist, or rain or snow, according to circumstances. The air is then said to be *saturated* with vapour or moisture; and if two masses of air, one colder than the other, and both saturated, come together, the mixed air will not be able to hold as much vapour as the two separate, so that some of the vapour will condense and become visible. According to the quantity of vapour in the air, it is said to be *dry* or *moist;* thus, if the air *can* hold 100 parts of vapour, but *does* only contain 75 parts, it is said to be only *three-quarters* moist, or to have 75 per cent. of *humidity:* if it had only 60 parts it would be only six-tenths moist, or have 60 per cent. of humidity. It is important to understand this, as we shall have to refer to it again.

Moisture or vapour in the air is absolutely necessary for life: a perfectly dry air would prove quickly fatal to both plants and animals, as all the moisture of the latter would be quickly drawn out by the thirsty air around.

Ozone is a gas that exists in very small quantity, but is probably of very great importance; it is a kind of intensely strong oxygen, which destroys organic matter, and has been called the *scavenger* of the atmosphere.

It is most plentiful in fresh pure air, least plentiful in places where men or animals are crowded together. It is now made artificially for certain purposes, such as bleaching.

Organic and Suspended Matters.—Some of these substances are found even in the purest air, but it is difficult to say what we ought to call normal (that is, according to rule), and what impurity. Some of the organic matter is probably in the form of vapour or gas; but perhaps the greater part is in small solid particles which float in the air, generally along with some inorganic matter. We are not usually conscious of the presence of those particles, unless they are in great quantity, as in a cloud of dust, or are thrown into a strong light, as when we observe the motes dancing in a sunbeam. Professor Tyndall ingeniously applied this last well-known fact to the examination of air for floating impurities. As sunbeams are not always to be had at command he made use of the more convenient ray of the electric light, and showed that air appeared illuminated or bright only when floating solid particles existed in it. These particles consist of *inorganic* matter, such as crystals of common salt, or particles of fine sand, coated or mixed with *organic* matter; the comparative lightness of the latter enabling the former to float about. When air is strongly heated, as can be done by passing it through a red-hot tube, the organic matter is all burnt away, and the inorganic or mineral matter, being left alone, is too heavy to remain floating in the air and so falls to the ground. This is proved by the air looking intensely black when the electric ray is directed upon it, showing that there are no solid particles to reflect it. For we must remember that we can only see a ray of light as it passes from its origin to an object, if there be solid or liquid particles in sufficient quantity and of sufficient size to reflect it to our eyes; if this is not the case we do not see the ray until it strikes some object. We can thus understand that a large quantity of organic matter may exist in the air, if there be mineral matter, or dust, to carry it. The objections to dust are, of course, obvious enough on this ground alone.

Of the suspended matters found in the outer air the following are the chief:—

1. *Mineral or Inorganic.*—Fine sand—Chloride of sodium (common salt).

Alumina (clay)—Peroxide of iron (iron rust).

Carbonate of lime (chalk)—Dried mud.

Phosphate of lime (bone-earth) — Carbon (charcoal or coal).

2. *Organic.*—Fragments of wood—Dried horse-litter.

Fragments of straw—Portions of insects, spiders' webs.

Hairs and other parts of plants, spores (or seeds) of fungi (small plants of the mushroom class), pollen of flowers in large quantities, numbers of small plants and animals, only to be seen by means of the microscope.

Some of those things are very important, on account of their effects upon man, especially the pollen of plants, which exist in very large quantity, and is believed on good grounds to be the cause of the distressing malady known as *hay-fever* or *hay-asthma.* This is a kind of cold that attacks many people just when the hay is ripe and is being cut—when the pollen (or powder) of its flower is being scattered about. It is found that the pollen grains of most plants produce this effect; but it is most severe when caused by the pollen of grasses (such as hay) or of trees of the pine or fir kind. The minute fungi and other plants and animals are also important, as they are sometimes believed to be capable of carrying disease to people, if they are not themselves occasionally the cause.

But the impurities in the open air are much less important than those which are found inside dwellings. Of course the outdoor impurities find their way in, but in the dwelling itself impurities are always being given off that float about the air, or settle on the walls, floors, ceilings, furniture and clothes, unless the ventilation is really very effectual. We find inside dwellings the following, in addition to those from the outer air:—

Fine splinters of wood from floors, furniture and utensils.

Charred wood, charcoal, particles of soot, tar, &c., from fuel.

Starch cells from flour and various articles of food.

Portions of vegetables, such as onion-peel, and the like.

Epithelium.—The peculiar scales which cover the skin in every part, and which are always being thrown off; these when pressed together, as by tight boots and shoes, become a hard, horny mass, and form *corns.*

Fibres of cotton, linen, wool, silk, and other materials of clothing.

Large numbers of minute moving particles called *monads*, *bacteria*, &c.

In the chambers of the sick, as in hospitals, we also find other things, such as

Pus cells.—These are very small circular particles, found in the *pus* or *matter* that comes from wounds and sores.

Particles from the *sputa*, or spit of persons with lung disease, such as bronchitis, consumption, &c.

Blood-cells, occasionally from the dressings of wounds.

Fatty particles, from greasy dressings, &c.

All these are very disgusting to think of and very dangerous to health and life, knowing as we do that many of them are capable of carrying disease from one person to another. Thus, *pus-cells* from sores may cause inflammation of the eyes, or may produce erysipelas (dangerous inflammation of the skin) or some form of blood-poisoning; the *sputa* from lung-diseases may light up similar diseases in previously healthy people; and *epithelium* (or skin-scales) may carry small-pox, scarlet fever, measles, or typhus. But on the diseases produced by foul air we shall speak further on, after considering a little the physiology of respiration, or the reasons and necessity for breathing air.

The Function of Breathing or Respiration.—Before going further it will be necessary to explain shortly the reasons why we require to breathe air and to point out the necessity for the air we breathe being pure. Our bodies are supported by taking in food and drink at certain intervals, according as they seem needed, the indications being the sensations of hunger and thirst. But in order to make the best use of food and drink they must undergo various changes in the body. Thus they must be *digested* by the stomach and the organs for that purpose; they must then be *assimilated*, that is, taken into the various parts of the body, which they have to keep up and nourish. Many organs, such as the stomach, bowels, liver, &c., are engaged in carrying out this great work, and the channel through which it is all done is the blood. Next, part of the food taken in is not suited for the purposes of the body, and must be got rid of, the tissues (or different kinds of matter of which the body is made) decay, and the products of their decay must be removed. These functions are accomplished by means of the *excreting organs*, viz., the bowels, the kidneys, the skin and the lungs, which respectively give out the fæces, the urine, the sweat and the breath. Now, none of those functions, so wholly necessary for life, could be carried on without *one* special substance, and that is the *oxygen* contained in air. All the changes that go on in our bodies depend upon that gas, so that its supply must be ample and continuous, on pain of immediate death if the supply be stopped, and grave illness if it be only diminished.

But another important function fulfilled in the process is the production of *animal heat* and *energy*. When fuel is burned, that is, made to combine with oxygen, in an ordinary fire, heat is produced, and this heat may be converted into energy in many ways ; as, for instance, by converting water into steam, which may be used to work an engine. In the same way the food combining with oxygen in our bodies gives rise to heat, which may be converted into energy when required. From this source arise all our powers of work and movement. The body must be kept up to a certain temperature, otherwise life would soon cease ; on the other hand, the temperature must not rise much above the standard, or it will rapidly waste away. The standard temperature, commonly called *blood-heat*, is $98\frac{4}{10}$ degrees of the common or Fahrenheit scale, and this is also the usual temperature of a warm bath. When food is regularly supplied and properly oxidized (that is combined with oxygen in the body) enough of heat is produced to warm the body up to this temperature, and to keep it there, for loss of heat is continually going on in consequence of exertion, evaporation from the skin, excretion by the bowels and skin, and the cooling effects of air taken into the lungs, and liquids into the stomach.

If food is not supplied in sufficient quantity, the tissues of the body are oxidized to supply heat and energy, and the body in consequence wastes, until at last it is no longer able to carry on its work, and death comes. This, in cold weather, will happen all the sooner if clothing be insufficient, for clothing economises heat by preventing it being radiated out into the air. Excess of work produces a similar effect to excess of cold—it causes a waste of energy (or heat, for the two are convertible) which must be provided for by an additional supply of food, on pain of the wasting of the tissues, and ultimate death. But if proper and sufficient food be supplied—if the clothing be sufficient and work moderate—the balance of heat is kept up in a wonderful way, for little or no difference is found in the temperature of the bodies of men in the hottest and the coldest climates. On the other hand, if the body is out of order, the temperature very quickly rises — an excessive oxidation goes on, and the tissues waste away; it then becomes the business of the doctor to control this waste as much as possible by the administration of proper remedies and nourishment; or the temperature may rise from derangement of the balance of functions, as for instance when the skin ceases to act properly, so that there is not sufficient loss of temperature to keep up the balance within. Now in all these cases the most important agent is the oxygen of the air, which must be constantly supplied as free from impurity as possible. About 12 to 13 cubic feet of pure oxygen are necessary every 24 hours, for the mere support of existence, for a man of average size and weight; and to this we must add at least half as much again as the amount required for his daily work. But we saw above that air contains only about 21 per cent. of oxygen, so that these amounts would represent about 60 cubic feet of air for absolute existence, and about 90 to 100 including daily work. But we must remember that this would mean that the air so used was completely expended, every particle of its oxygen being consumed and combined with other matters. We shall see, however, presently that it is impossible to do this, and that therefore the supply of air must be enormously greater in order to support life. Before we consider what this quantity must be we must briefly describe the actual process of respiration.

Respiration consists in the taking in of air into the lungs, the distribution of the oxygen in it through the body by means of the blood, and the giving out again, through both lungs and skin, of the waste matters which can be got rid of in a gaseous form. The blood being the main agent and channel, it is necessary to understand its process of circulation. The blood is contained in the *heart*, *arteries*, *veins*, and *capillaries*, all which form one continuous cavity, without a break in its walls in a state of health. The *heart* is the great reservoir and force-pump which receives the blood and pumps it out to the different parts of the body. The *arteries* are the vessels which carry it to all parts of the body; as they are only full while the heart is in action, they become empty when death takes place; on this account the ancients gave them the name of *arteries* or *air-vessels*. When the arteries, in proceeding to different parts of the body, divide into smaller and smaller branches, they at last become so fine as to be invisible to the naked eye and to require the aid of the microscope to be seen; they are then called *capillaries* or hair-like vessels, on account of their fineness. When they have reached their smallest size they begin again to unite and form larger and larger vessels, which, when they become sufficiently large to be visible to the naked eye, are called *veins;* these carry the blood back to the heart again. The circulation is thus continuous, although it is modified in various ways during its course in order to accomplish the proper nutrition of the body. The most important modification is what is called the *pulmonary* or *lung* circulation, and so important is this that the circulation is generally roughly divided, in description, into the *pulmonary* or *lung* circulation and the *general* or *systemic* circulation. The lung-circulation is carried on in the same way, the blood being pumped by the heart into the lungs, through the pulmonary artery which divides in the lungs and forms capillaries; these again reunite and form veins which carry back the blood to the heart. The term *artery* must be understood to mean a vessel which carries blood *from* the heart, and the term *vein* a vessel which carries blood *to* the heart. In the general circulation the arteries carry *bright red* blood and the veins *dark* blood; in the lung-circulation it is just the opposite, the *arteries* carrying *dark* blood and the *veins bright red* blood. The capillaries again are to be looked upon as the small vessels which form the channel or junction through which the arteries and veins communicate. The blood itself is a clear fluid in which float a large number of disc-like bodies, called *globules* or corpuscles, the greater part of them red, but some white. The red are very small, although much the most numerous; about 3,000 of them would go to an inch; the white, larger in size, are less numerous. Whilst the white globules are apparently chiefly employed in the *nutrition* of the body, the red would appear to be the chief carriers of oxygen. Although the fluid of the blood can easily pass through the walls of the vessels, and fluids from without can pass in, the globules cannot do so unless the walls are cut or torn. Once *blood*, as a whole, gets out of a vessel it becomes a *foreign body*, and must be disposed of in some way, but the whole nutrition and conservancy of the body are carried on by the interchange of *fluids* through the walls of the capillaries. The blood requires to be supplied with *food*, *water*, and *air* ; the air is supplied through the lungs: the water chiefly through the stomach, from which it is absorbed: the food through the stomach and intestines, from which it is gradually absorbed by smaller vessels, called lacteals, which finally unite in a slender tube called the *thoracic duct*, and this pours the nourishment into one of the great veins in the right side of the neck, by which it is eventually carried to the heart. The heart is divided into two halves which have no direct communication with each other; each half is again divided into two, an auricle and a ventricle, with an opening between them; this opening is provided with a valve which allows blood to pass from auricle to ventricle, but not the reverse way. The blood is thus received into the right auricle, from which it passes into the right ventricle; as soon as this is full it contracts strongly and drives the blood into the pulmonary artery, the entrance to which is provided with valves to prevent the blood flowing back. This blood, which is dark as it enters the lungs, flows through arteries and capillaries, giving off carbonic acid, water, organic matter, &c., and taking in oxygen, until the red globules are fully charged; it then flows through the pulmonary veins as bright red blood, into the left auricle; from this it passes into the left ventricle. When this is full it contracts with great force, driving the blood into the aorta or great artery of the body, from which it flows to all parts until it reaches the minute capillary vessels. In its course it parts with its nutritive material and its oxygen to each tissue and organ, taking up in return the products of oxidation and disintegration; it then flows through the veins as dark blood, until it is finally delivered once more into the right auricle of the heart. In the course of its journey it delivers up the urine to the kidneys, the bile to the liver, and the various secretions to the different organs and tissues as required. If the organs are incapable of performing their functions and those substances are left in the blood, disease and death are the results, according to the nature and extent of the derangement. As all this complicated work is dependent upon the regular and constant supply of oxygen, the immense importance of respiration may be easily understood.

Now what are the changes the air undergoes in the lungs? These have been carefully examined, and the result has shown that the air breathed out of the lungs contains less oxygen, but a good deal more watery vapour, carbonic acid, and organic matter than it did before. About 5 per cent. of oxygen is lost and about 3 to 4 per cent. of carbonic acid gained, or rather more than *one-fourth* of the oxygen is absorbed whilst the carbonic acid is increased about *one hundred times*, as is also the *organic* matter. Such air, although still containing more than enough of oxygen, would soon be unfit to support life for several reasons. 1.—It is found that a mixture of pure nitrogen and oxygen becomes unbreathable if the oxygen falls to one-third of the quantity in fresh air, that is, from 21 per cent. to about 7 per cent.; so that air twice rebreathed would on that account alone become irrespirable. 2.—It is found that even if the quantity of oxygen were still sufficient, the presence of 10 per cent. of carbonic acid renders the absorption of oxygen impossible; the same air breathed twice would bring up the carbonic acid to nearly that amount. 3.—The organic matter from the lungs has a rapidly poisonous effect, soon causing delirium and stupor, unless quickly and largely diluted. We have thus three absolute reasons for a copious dilution of the air in which we live. But the above are, of course, extreme cases, which find their justification in such events as suffocation in mines and holds of ships, in the Black Hole of Calcutta, and the like; but there are other less sudden and immediate consequences, which are the more important as being much more frequent and constant. Most people feel the effects of confined air after a short time, as shown by headache, lassitude, and incapacity for exertion, either physical or mental, and this state of things, prolonged for a time, results in permanent ill-health, which may show itself in many ways. We need not be surprised at this when we reflect upon the extraordinary delicacy of the lung-structures, the cells of which are subdivided to such a degree of fineness that there at last remains only a membrane, between the air and the blood, of such delicacy that even powerful microscopes are incapable of making it visible. Of these cells there are probably not less than *five or six millions*, representing a surface of about 12 square feet, in the lungs of one person. Now the whole blood is exposed to this remarkable surface *sixty* times every hour, or 1,440 times in the 24 hours, so that if there be any poison in the air breathed the chances of escaping it are small. Consider, therefore, the dangers to which we are exposed by the continued breathing of air rendered foul by any cause! And yet a large number of people—we may say the majority—are continually exposing themselves to this danger with scarcely a thought of the risks they run.

Among the diseases which claim their share of victims year by year, there is one class which is especially fatal, both directly and also indirectly, by lowering the tone of health and resisting power, and laying the sufferers open to the attacks of other diseases. This is the class known as *scrofulous* diseases, including *consumption*, which of itself kills about 80,000 persons in the United Kingdom every year; or, it accounts for about eleven out of every hundred deaths. If to this class we add the diseases of the lungs (other than consumption) and of the heart,* and one or two other forms of disease, we shall find that out of every 1,000 deaths about *one-fourth* are due to causes arising in connection with the rebreathing of foul air. And this is by no means the only loss, for we must remember that for every case of death there are many cases of sickness and ill-health, which lead to loss of income and diminish the power of productive work. While, therefore, the deaths from this cause amount to nearly 200,000 per annum, the list of the more or less sick and ailing must be raised to ten times that number. It is easy to understand from these numbers, not only the amount of personal suffering, but the amount of social misery and pecuniary loss to the community that arise in this way. It had long been the opinion of medical men that foul air was a cause of scrofula and consumption, and this opinion was finally confirmed by the careful inquiries made into the health of the army and navy, which brought out the fact that our soldiers and sailors, who ought really to have been healthier, were actually dying at a greater rate than people in civil life. It was shown conclusively that the cause of this was foul air, arising from want of ventilation in their barrack-rooms and on board ship between decks.

* There are, of course, other causes of heart-disease; but many more cases are due, directly or indirectly, to the breathing of foul air than is generally believed. A large number are secondary to diseases of the lungs, which are themselves directly referable to foul air as an exciting cause.

Thirty years ago consumption killed nearly *eight* out of every thousand of our soldiers every year; *now* it kills barely *three*. Formerly *two* soldiers died of consumption for *one* civilian of the same age; *now*, *four* civilians for every *three* soldiers. Again, investigations into the diseases of animals have shown that they are also liable to the same dangers. Dogs in badly-ventilated kennels, horses in ill-ventilated stables, monkeys in unventilated houses—are all liable to die with the usual symptoms of galloping consumption. In addition also to the immediate evils produced, the form of disease thus lighted up becomes hereditary, that is, it can be transmitted from parent to child, so that its effects are felt in remote generations. It is also found that even healthy persons, living with scrofulous or consumptive persons, are liable to take the disease, and all the more rapidly the less well ventilated the dwelling is. All diseases of a contagious or infectious character are much aggravated in close, ill-ventilated places, especially small-pox, scarlet fever, typhus fever, &c. Indeed, one of the essential causes of typhus fever and plague appears to be crowding of poverty-stricken and destitute persons together in a badly-ventilated space.

On the other hand, the advantages of copious supplies of fresh air are very great. Fresh air, properly and continuously supplied, undoes much of the evil which foul air produces. It restores the vital powers of the patients themselves, and it rapidly removes or copiously dilutes the disease-poison given out into the atmosphere. In diseases such as typhus fever or plague, it is sometimes sufficient to turn the sick out into tents and scatter them well in order to stop an epidemic. In tents or in huts, or indeed almost in the open air, is the most favourable condition for treating typhoid (or enteric) fever and small-pox. Wounds and sores, which tend to erysipelas and hospital gangrene in foul air, heal rapidly and well in fresh air; whilst even scrofula and consumption are greatly mitigated and may be even arrested by living in a pure and frequently-renewed atmosphere. It may be laid down as a general rule that foul air is the most constant, the most wide-spread, and the most serious cause of disease that exists. We can abstain from bad or poisonous food, we can refrain, for a time at least, from impure water, but we are bound to take the air as we find it and at the moment, under penalty of speedy death. No time can be allowed for reflection or waiting for a better supply; we *must* breathe or die of suffocation, even if the air we do breathe be loaded with a surely fatal poison. Therefore any impurity that may be present in the air is much more certain of working ill effects than under any other condition; the dose of poison may be more concentrated when taken in drinking water or in food, but the effects from air poison are much more constant and certain in their working. Thus, when we find a *sudden* outbreak of disease in a community, the chances are that it has something to do with bad food or impure drinking water, most frequently the latter. When, however, the outbreak is not sudden, but prolonged and lasting, it is almost certainly connected with foul air. It is further to be noted that even where positive disease is not recognised, there is a general lowering of tone and strength, which is both a loss in itself and also lays the individual more open than he would otherwise be to the attacks of positive disease. Now the sudden, severe outbreaks of disease are few compared with the long list of slow insidious maladies and the general low tone of health among a large proportion of one community, a proof that foul air is undoubtedly the most constant and serious cause of disease. Another important thing is that foul air, since it diminishes the amount of oxidation in the body, diminishes also the available amount of energy for work and the amount of appetite for food. In this way a properly ventilated workshop is about the best investment an employer can make, for he will thus get more and better work done in the same time. These remarks apply with equal force to mental or head work and to manual or hand work.

Quantity of Air Required.—Let us now consider how much air is necessary for health, what, in fact, constitutes complete and thorough ventilation. To determine this we must have some basis to go upon, and the best that we can propose for ourselves is to get the air of our habitation to resemble the pure open air as much as possible in its quality, and to follow out the plan of Nature, as far as we can, in our methods for accomplishing this. We have already seen that under most ordinary circumstances the air even of towns is not very impure out of doors, if we take the carbonic acid, for instance, as our measure. Thus, in London for example, within an area of about 200 square miles there are not less than four millions of people who are constantly giving off carbonic acid from the lungs and skin; a large number of horses and other animals who are adding their share, and an immense quantity of fuel and gas being constantly consumed and adding still more to the atmosphere. It has been calculated that the quantity is sufficient to double the carbonic acid in about 14 *cubic miles* of air every twenty-four hours, that is, the whole mass of air to the top of St. Paul's Cathedral. But, when we analyse the air in London streets on a fairly clear day, we find that it shows only a very small excess over the air of the fields beyond the town; and if there is anything like a brisk breeze there is hardly any difference at all. It is clear, then, that the change of air must be very great and very complete to admit of such rapid diffusion; masses of air must be in constant motion, taking away the vitiated or poisoned air from the centres of habitation and diffusing it among the purer air of country districts, where it is quickly absorbed by vegetation, and goes to form the grass, fruits, and vegetables which are consumed by men and animals, and the trees which yield us fuel as well as materials for arts, trades, and manufactures. Now, although it would be difficult in our habitations to effect such a change as would completely imitate the operations of Nature on a grand scale, we must nevertheless make as near an approach as we can. We use the carbonic acid as a convenient measure of the air's purity, although it is not itself the substance whose evil action we dread; what is really dangerous is the organic matter which is given out along with it; but experience has shown that there is a tolerably constant relation between the amount of carbonic acid and the amount of organic matter, and as the former is more easily determined, it is generally adopted as the indicator. It is usually admitted in the present day that, if there is no appreciable difference between the air of a room and the outside air as judged of by the sense of smell, the ventilation of the room is good, and that according as a close smell is more or less perceptible, so is the ventilation better or worse. This of course presupposes several conditions: 1st. That we are dealing with fairly cleanly people, who do not allow accumulating of dirty clothes or other sources of organic matter in their habitations; 2nd. That there is no special odour of scent or other substance which artificially masks the real smell; 3rd. That the smell is judged of by entering the room as directly from the open air as possible. Nothing is so soon dulled as the sense of smell, a fact which must be within the experience of most persons; for let us leave a church, theatre, ball-room, or even ordinary sitting-room, and return again from the open air, how foul and offensive the atmosphere seems, although to those who have remained the whole time its condition is probably not perceptible! Or let us return to the bedroom, which we have not long left, before the window has been opened and the room flushed with air, in most cases the smell of closeness is only too perceptible, if not absolutely offensive. It has been found experimentally that this smell is in nearly direct proportion to the organic matter, and also that it does not become perceptible until the organic matter has reached a certain amount. Anything below that amount, that is, a state of atmosphere which is indistinguishable by the sense of smell from the external air, may be looked upon as good ventilation. I have made a large number of experiments on this subject and have found that this limit of smell is reached when the carbonic acid due to the impurities of respiration reaches two parts in 10,000 of air by measure, over and above the ordinary amount in average pure air. This is nearly 50 per cent. more than ordinary external air contains, and it therefore leaves a tolerably wide margin between possible artificial ventilation and the great air-changes effected by Nature herself. If, however, we can so change the air as to keep down the amount of impurity to this quantity, we shall in most cases have an atmosphere so far pure that no difference between it and the open air will be perceptible by the sense of smell. In order to do this we must know how much impurity is likely to be given off in a certain time. There are two main sources of impurity, namely, *combustion* and *respiration;* for the former, so far as fuel is concerned, a special outlet is usually provided in the shape of a chimney, although in the case of lights (gas, lamp, or candle), this is not so often attended to; for the latter (respiration) such special direct outlet is not practicable, and therefore dilution must be had recourse to as well. The food that an average human being consumes varies according to the condition he is in and the work he does, but it may be laid down that the smallest daily amount which will support life, even in a state of complete rest, contains about 18 or 19 grains of carbon for each pound weight of body; this, when oxidized, would produce about 150 cubic inches of carbonic acid; consequently, a person weighing only 9 stone (126 lbs.) would produce daily about 11 cubic feet of carbonic acid. But as we are not always in a state of absolute rest, even the laziest of us undertaking some exertion, we must make some considerable additional allowance—about *one-half* more being a fair average; this raises the daily amount of carbonic acid to about 225 cubic inches per lb. weight of body, or a total of 16 to 17 cubic feet for 9 stone weight. That this estimate is fairly accurate has been proved by the experiments of Professor Pettenkofer of Munich, who found that the daily amount given off, with gentle exertion during the day and complete rest at night, was about 232 cubic inches per lb., or about 17 cubic feet per diem for a weight of 9 stone. This gives about $\frac{7}{10}$ (seven-tenths) of a cubic foot of carbonic acid given out every hour. In order to dilute this to the extent we have laid down as our standard we must mix it with 5,000 times its bulk of air, or supply 3,500 cubic feet of air every hour our room is occupied; and this is the standard which ought to be adopted for men, that is, adult males. In the case of women and children, whose weights are less, some modification might be suggested, but we must bear in mind this, that in children and young people, at least up to the age when growth stops, the changes going on in the body are more active, so that although the actual amount of carbonic acid given off may be less, it is not less in the direct proportion of the relative weight, and therefore more air proportionally is required. On the other hand, old people in the decline of life, whose tissue-changes are less active, give off less proportionate carbonic acid, and consequently require rather less than the proportionate amount of air. We must, however, be cautious not to make our allowance too small to ensure health for all ages and sexes.

If we adopt about 100 lbs. (7 stone 2 lbs.) as the average weight of human beings, we shall, I think, not be erring on the side of excess; this will give us a proportion of air to be supplied to each person—whatever be the sex or age—amounting to 2,800 cubic feet per hour, or 67,200 in the 24 hours. The number usually adopted at present is 3,000 per hour, or 72,000 in the 24 hours, not differing very largely from the one we have arrived at. We may therefore lay down as a safe rule that, for the ordinary purposes of life, each person ought to be supplied with 3,000 cubic feet of air every hour, if he or she is to be kept in the fullest health. This must be looked upon as the *minimum* (or lowest quantity); everything that necessitates increased exertion, or that gives rise to more impurity, calling for a larger supply of air, so that workshops, school-rooms, sick-rooms, and hospitals, ought all to be more amply provided.

We have to consider the possibility of providing this quantity of air, and the ways in which it may be done. And here we find ourselves very much hampered by other difficulties, which show that in this, as in many other things, what is desirable is very far from being the same as what is immediately attainable. If we try and conceive what 3,000 cubic feet mean it will at once be seen that there is serious difficulty attending the supply of so much air. By means of ordinary appliances it is seldom possible to get the air of a room completely changed oftener than three times in an hour, and indeed this is not often reached in many cases. It is also a serious question, in a climate like ours, how we are to keep the temperature of a room up to a fair height under the circumstances. Now, if we are to supply 3,000 cubic feet of air an hour, it follows that if the air is changed three times, its size must be 1,000 cubic feet; this represents a room measuring 10 feet in every direction for each person, or a room for two persons would have to be about 16 feet long, 12 broad, and 10 in height. How seldom it is that such an amount of space is available! Among the poor the space is often less than the quarter of this, although the law lays down that in common lodging-houses not less then 300 cubic feet shall be given in sleeping-rooms, and at least 400 if the room is to be used as a day-room as well. I think 500 is the smallest amount per head that ought to be permitted in sleeping-rooms, whilst every effort should be made to obtain at least 1,000; we allow our soldiers in barracks 600, free of all deductions. Of course the great difficulty is the question of expense; a larger space means more rent—especially serious to the poor in towns—and also greater expense for fuel to warm it. If, however, only 400 cubic feet of space be the quantity allowed, it follows that the air must be changed at least *seven* times an hour, in order to give the desired amount—a state of things that we must admit to be practically impossible. We may still, however, make an effort to approach as near the desired point as possible, and much may be done with a little ingenuity, once we are fully convinced of the necessity of it.

Connection between Cubic-space and Air-supply.—It is a very common notion, and one that it is sometimes difficult to remove, that a deficient supply of air may be made up for by increasing the size of the room we occupy, or, in other words, the larger the room the less necessity there is for a supply of fresh air. This is quite an error if the room is to be occupied for more than a couple of hours, consequently it cannot apply in any way to an ordinary dwelling-house. This can, I think, be made plain by an example. We wish, as before stated, to dilute the poison (reckoned as carbonic acid) 5,000 times, in order to preserve a proper condition of purity; to do this about 72,000 cubic feet of air are required in 24 hours. Let us suppose that the air in the room is pure to begin with, and that the size of the room is 500 cubic feet; then the total air supplied in the 24 hours is just 72,500 cubic feet. If, on the other hand, the size of the room is 1,000 cubic feet, then the total air will be 73,000, or the difference will be 500 in favour of the larger space, or about $\frac{1}{146}$ of the whole. But if the room is occupied both as sitting and sleeping-room—a state of things only too frequent—it may happen that it is in continual occupation for days or for weeks, or more. But at the end of the first 24 hours the condition of the air of the room has reached the highest amount of impurity that is admissible, therefore it is no longer to be reckoned as part of the pure fresh air supplied. Consequently the difference at the end of two days would still be the original 500 in favour of the larger room, but the proportion would have to be calculated on 144,500, or the difference would be only $\frac{1}{289}$ of the whole, whilst at the end of a week it would be $\frac{1}{1009}$, an amount that would not be in any way appreciable as having any material influence in diluting the poison. We may state it in another way by pointing that the air in 500 cubic feet would, if fresh, suffice for about *ten minutes'* ventilation, in 1,000 cubic feet for about *twenty minutes*, so that the difference in favour of the larger space would amount to about *ten minutes*, a quantity quite insignificant when compared with continuous occupation. Even a space so large as 3,000 cubic feet would only represent the gain of 50 minutes over a space of 500. It must therefore be borne in mind that if a room, or indeed any space, is to be *continuously* occupied, that is, occupied for more than a couple of hours at a time, the same amount of fresh air must be supplied, whether the space be large or small, and that size can never make up for want of *fresh* air, except for a very short time—a time which is always less than *two* hours.

It will of course be understood that the advantages of plenty of space are not to be underrated; indeed, we desire to get as much space as possible; but it is necessary to understand very clearly that the necessity of fresh air is not at all altered by enlarging the space, although the enlargement of the space may increase our comfort, and the ease with which the ventilation is carried on.

There is another error which is apt to be made, and that is to consider the gross size (or capacity) of the room, as all that is required to be looked to. Thus a room of 1,000 cubic feet will be held sufficient for two persons—supposing each is to have 500—no regard being had to the shape of the room; and it is very often supposed that a lofty ceiling makes up for deficiencies in length and breadth. This is a grave error when pushed too far. A certain height of roof is of course necessary, but a certain amount of floor-space is not less so; indeed, of the two, if one must be sacrificed at the expense of the other, it is better to lower the height than contract the floor-space. The limit of height may be conveniently placed at 12 feet, which is quite high enough for all ordinary rooms; anything above this ought not to be reckoned as efficient space. Therefore, if we put 500 cubic feet as the space for each person, the twelfth part of this will represent the floor-space in square feet, or 42 square feet; this is a space about 8½ feet long and 5 wide, surely a small enough space for a bed, &c. If the height is less than 12 feet, then the floor-space must be greater; at 10 feet it would be 50 square feet; at 8 feet it would be 62. Soldiers in barracks are allowed 50 square feet, with 12 in height, giving a total of 600 cubic feet, an amount which is looked upon as the very smallest which can be allowed with safety. If, however, a larger space were fixed upon, say 1,000 cubic feet, then the floor-space would require to be about 83 square feet (about 12 feet by 7) with 12 feet in height. By paying attention to the two conditions of floor-space and total space, we shall steer clear of any grave error. The importance of the principle may be understood by considering the condition of a man placed at the bottom of a pit or well; the space above him is illimitable, but from want of lateral space he runs a very good chance of suffocation. Similarly, it has happened that people have been suffocated in a crowd in the open air, where also the space upward had no limit, but where lateral space was wanting. The amount of lateral, or floor space, ought therefore always to be stated, along with the total cubic space, so as to leave no doubt about the way in which the dimensions should be distributed, and thus to fix the shape of the room within safe and healthy limits.

But after we have got so far there is still another point of importance, and that is the question of the furniture in the room. It is not enough to provide nominally so much space, bounded by the requisite height, length, and breadth; we must see that the space is really available for the purposes of respiration. Thus, a bedroom may be nominally 1,000 cubic feet, but if a large part of it is filled with heavy furniture it is obvious that so much space is taken away from the breathing-room. A heavy wooden bedstead, with large curtains, a bulky wardrobe or unwieldy chest of drawers, will soon absorb 200 or 300 cubic feet, and so diminish both the floor and cubic space of the inmates. Bulky articles of furniture should be avoided as far as possible; curtains and hangings are chiefly receptacles for dust. Metal bedsteads are the best, take up the least room, and are the most easily kept clean. The cubic space laid down as the least that should be given must be understood to be independent of that occupied by furniture, which must be separately estimated for. Even the occupant himself takes up space, but as this is only from 3 to 5 cubic feet, it is scarcely material out of 1,000.

Methods of Delivering and Extracting Air.—Ventilation, or the proper renewal of air, is generally divided into two kinds, natural and artificial. No very sharp line can be drawn between them, but the former (natural) is usually understood to be any plan that requires no special apparatus involving much labour or expense for working it; the latter (artificial) is understood to mean any plan which involves a more or less constant expenditure of labour or money, or some special and generally costly apparatus. On the other hand, strictly speaking, the merely lighting of a fire is an artificial method, but as the fire is nearly always required for other purposes, there is not necessarily a special expenditure for ventilation.

All change of air depends upon some force or pressure being applied, and this may be done either by direct power, such as may be applied by means of a pump, or by a difference of temperature. By direct power we can drive air into a room or pump it out, and these plans are frequently used in dealing with large buildings; but, generally speaking, they are not adapted for ordinary dwellings. In most cases special plans of ventilation have been too elaborately contrived, and the very arrangements intended to favour the movement of air have tended rather to obstruct it. Our object ought to be not to *drive* air so much as to *lead* it; to imitate, in short, nature as far as we can in our operations. The atmosphere itself is continually in movement, both up and down and on all sides, the movement being caused by changes of density, produced by heat and moisture. If, therefore, we simply remove obstructions to the movement of air we shall, in most cases, do all that is wanted to accomplish our end.

There is a mistake into which many people fall in this matter, namely, to confound ventilation with draughts; they object to ventilation because it gives them cold. Now, in the first place, ventilation and draughts are not only not the same thing, but are really opposed to each other; for true ventilation is the gradual, constant, and imperceptible change of air, such as takes place in the open air, say, on a mild day, and of which we are at the time unconscious. In the same way our houses, if properly ventilated, will have the air changed in such a way as shall be imperceptible to the inmates, except from the fact that there is no disagreeable sensation felt at any time. Persons who live in such an atmosphere have no fear of cold draughts of air, and encounter them with impunity; for cold currents of air have little power of themselves to produce disease, unless carried to an excessive extent, either as regards lowness of temperature or length of exposure. The main cause of colds, &c., is the disturbance of the system produced by the constant breathing of foul air, after which the cold current when it comes finishes the work. If our theatres, ball-rooms, churches, &c., were better ventilated, we should hear less of severe and often fatal colds following a visit to them, not to speak of the absence of the headache, malaise, and exhaustion which so often follow such gatherings.

What then are the essentials of good practical ventilation?

1.—A complete and continuous change of air, so that at no time the amount of impurity shall exceed the standard.
2.—The change of air so controlled that at no time there shall be a current or draught perceptible to the inmates.
3.—A degree of temperature sufficient for health and comfort, but not too high.
4.—A condition of humidity of atmosphere, neither too dry nor too moist.

All these are necessary for real health and comfort, for efficiency for work, and for the obtaining of refreshing repose. They are also all more or less connected together, but the two first and the two last are more specially connected with each other.

We have already seen that 3,000 cubic feet of air ought to be supplied to each person every hour, if possible, in order to keep down the impurity to the standard admissible. Now, if we can settle the velocity or rate of speed at which the air is to move, we can easily calculate the size of opening which it is necessary to provide, leaving the shape and arrangement of it for after consideration. A good deal depends upon temperature, but taking the average temperature of our own climate, about 50° Fahrenheit, it is found that there is a certain point at which a current of air begins to be distinctly felt. Air moving at the rate of 2½ miles an hour, or about 3½ feet a second, is perceived as a current by all persons; the half of this rate, or about 1¾ feet a second, is rarely perceived. What is usually called a still air, that is, an air which scarcely moves an ordinary wind-gauge, is actually moving at the rate of about 1½ mile an hour, or a little over 2 feet a second. We may, therefore, assume, as a rule, that the current of air ought not to be more than 1¾ feet a second in any part of the room, if it is air at the same temperature as the room, and even less than this if the temperature is lower. If the air is cold, or still more if it be cold and moist, it is felt much more easily; whilst, on the other hand, a much more rapid current can be readily borne if the temperature of the incoming air is higher than that of the room.

It is found practically that, if the openings for the coming in and going out of air are properly arranged, a rate of 5 feet a second at the point of entry will secure a sufficient change of air without there being an unpleasant draught in any part of the room. Now, if we require 3,000 cubic feet an hour, we may find the necessary size of our opening in this way:—Suppose the opening to be 1 square foot (144 square inches), then 5 feet every second will give exactly 5 cubic feet. There are 60 seconds in a minute, then five times this gives us 300 cubic feet every minute; multiplying again by 60 (the number of minutes in an hour) we have 18,000 cubic feet every hour. But, as we require only 3,000, and as there are 6 times 3,000 in 18,000, only *one-sixth* of that size of opening is necessary, or one-sixth of a square foot, or dividing 144 by 6, we have 24 square inches as the size of opening for each person for the purpose of bringing in fresh air.

But, if we bring in air into a room we must take an equal quantity out; so that, if 3,000 cubic feet are coming in at one part, the same bulk of air must be going out elsewhere from the room. Consequently, we must supply an additional amount of opening for this purpose to the same extent as for the incoming air, or 24 square inches also. We have thus 48 square inches of ventilation opening required for each inmate. This, if properly disposed, will be sufficient to provide the necessary movement of air for good ventilation.

What is the power which will so move the air as to make it enter and go out by those openings? Partly the wind, but much more the difference of temperature between the inside and the outside air. The air in a house is generally warmer than that outside, and the outer air is therefore heavier, because it is colder. The cold outer air presses downwards, by attraction of gravity—just as a stone drops from a height—and pushes the warmer air upwards. The rate at which it presses downwards depends upon the temperature and upon the height from which it falls—the higher the elevation the greater the velocity when it gets near the ground. A stone falling from a height falls 16 feet in the first second, 64 in two seconds, 144 in three, and so on; and the cold column of air follows the same rule. In estimating the height through which the cold air passes, we usually measure from the floor of the room to be ventilated to the point where the foul air goes out, which may be, for instance, the top of the chimney. If we have, for instance, a ground-floor room to ventilate, say in a three-storied house, the height of each floor being about 10 feet, and making allowance for the space between the floors and the further height of the chimney, we should probably have a height of about 42 feet from the floor to the top of the chimney. If now we have a difference of 20° F. in temperature (outside 40° and inside 60°), we shall find that this would give us a speed of air-movement equal to a little more than 10 feet a second; or this would give us more than 6,000 cubic feet per hour through our 24 inches of opening. If the difference of temperature were only 10° F., then we should have about 4,000 cubic feet, and at 5° F. only about 3,000. But we could not depend upon getting all this, because there are various causes of hindrance, such as the narrowness of openings, the soot in the chimney, &c., which cause what is called friction, acting just like a drag on the wheels of a carriage. We must make some allowance, amounting generally to at least one quarter, and sometimes even more. This would reduce the above numbers thus—allowing one quarter for loss:—

20° F. difference	4,600
10° F. „	3,300
5° F. „	2,400

Now, if we go to the first-floor of our house and calculate the quantity of air there, we shall find a difference, because the height from the floor to the top of the chimney will be only about 31 feet instead of 42. Accordingly, we find the above numbers altered thus—always allowing one quarter for loss:—

20° F. difference	4,000
10° F. „	2,800
5° F. „	2,000

If we ascend still further to the top floor, where the height will only be about 20 feet, we shall find a still further lessening of the quantity we may expect to get, making the same allowance as before:—

20° F. difference	3,200
10° F. „	2,300
5° F. „	1,600

If, on the other hand, we are dealing with a small cottage, the total height from the floor to the top of the chimney being, say 12 feet only, then we should have—

20° F. difference	2,500
10° F. „	1,760
5° F. „	1,250

From the above we may understand several points:—

1. That with 48 square inches of inlet and outlet opening we may get a considerable movement of air, even in comparatively warm weather.

2. That sometimes in cold weather the speed of the current may be greater than we want.

3. That in upper floors and single-storied dwellings there is greater difficulty in getting the air changed than in the lower stories of larger dwellings.

From these considerations we draw some practical hints:—

1. In cold weather some of the incoming air ought to be warmed, in order to enable us to provide enough without cold draughts.

2. In warm weather the deficiency of air coming through the ventilators must be made up, either by having larger additional openings which we can make use of, or by opening doors and windows.

3. That in upper floors and in single-storied buildings the amount of ventilation opening ought to be somewhat larger than in the lower stories of larger

buildings. Thus, if 48 inches be the ordinary amount for a ground floor of a three-storied building, a few additional inches ought to be added for each story as we go up, a cottage or single-floored dwelling being treated as a top-floor, because the height is so small.

Among the causes of obstruction to the movement of air are the following:—

1. Irregularity of shape of opening.
2. Clogging of opening with dust, &c.
3. Too great length of tube or shaft, compared with its width.
4. Too much bending or twisting of tube.
5. Dividing the opening into too many parts.

1. With regard to irregularity of shape, the simplest form is always the best—the circle and semicircle being the most advantageous, and next to that the square.

2. Clogging with dust takes place when the opening is too small, or closed up with a grating or wire gauze, or with soot, if it is connected with a chimney.

3. If the throat of the opening be too small in proportion to the length of a tube the friction is very much increased, so that only a small part of the air expected passes.

4. If a chimney or tube be bent or twisted in its course, a great loss of movement takes place; if a tube is bent at a right angle, one-half of the air-current is lost, if there be a second right angle, only one-quarter of the current is obtainable. If a tube is both long and bent it is hardly possible to reckon upon the movement with any degree of confidence.

5. It is a common practice to divide the openings for ventilation into a number of smaller ones, and in some cases this is convenient, but the error committed is to think that a number of small openings, the *sum*

of whose size is equal to one larger one, is as useful as the one large one. For instance, suppose we have an opening 10 square inches in size, and it is found convenient to supply a number of small ones instead of the one large one, the common plan is to give, say, 5 openings of 2 square inches as equal to the one large one of 10. It is quite true that 5 times 2 are 10, but it is *not* true that you can get *one-fifth* of the amount of air through each 2-inch opening that you would get through the one 10-inch. The fact is, that you cannot count upon more than *one-sixteenth*, so that to make up ventilation opening with separate 2-inch openings equal to one 10-inch, you would have to provide 16 instead of 5, because 32 square inches so divided are only equal in usefulness to 10 square inches in a single opening. I have sometimes seen a dormitory ventilated by means of a pipe passing along, supposed to bring in fresh air; the size of the pipe might be, say, 2 square inches; it is considered necessary to provide, say, 10 square inches by this means; accordingly, a number of small holes, each about $\frac{1}{8}$th of a square inch, are made in the side. If 80 of these are made then the idea is that 10 square inches are given. Now in a pipe like this you can never get more opening than the size of the pipe itself, namely, in this case 2 square inches, so that all you do by such a plan is to distribute 2 square inches over 80 small holes, which is not necessarily an advantage in all cases. Besides this, even with those 80 holes, the full advantage of the 2 square inches is not obtained, for the greater part of the current will pass along the pipe itself, and only small portions will find their way out at the holes, which do not lie in their direct line and whose small size forms a serious obstacle to a free exit of air.

These are some of the important points to be attended to, and some of the errors to be avoided, in arranging for practical ventilation.

Let us now consider the kinds of openings most suitable, and their arrangement and position.

Inlets for Fresh Cold Air.—The position for cold inlets has been a good deal discussed, some recommending them at the floor-level, and others at the ceiling. In warm weather, inlets at the floor-level are well enough, and they certainly have the advantage of effectually ventilating the lower part of the room, but in most cases, and especially in cold weather, they chill the feet and are not long submitted to. When they are placed near the ceiling the air sometimes does not distribute itself properly through the room; but passes at once to the outlet. Now, the essence of good ventilation is that *all* the air shall be completely changed, or, in other words, that the incoming air shall be properly distributed. Therefore, in arranging our openings, we must see that the air is so brought in that it shall thoroughly mix with the air of the room, so as to dilute the impurity as much as possible. Floor-inlets might do this, but if they bring in cold air only they are too cold for our climate. We must therefore look to other inlets delivering at some height from the floor. Of those there are several kinds, viz.:—

I. Openings at the windows.
II. Openings at the floor line with upright tubes.
III. Openings in the walls.

It must be distinctly understood that in all cases the openings are to be direct to the open air, and not to any other room or passage. *Door-inlets* are not at all to be recommended.

I. *Openings at Windows.*—Every window in every house ought to be made to open, even if it be generally kept shut. There is no way of thoroughly flushing a house with air except by widely-opened windows. But the window used in the ordinary way is not a good kind of ventilator, for in cold weather it causes a draught which is unpleasant. Arrangements, however, may be made to obviate this.

1. Small slits may be made in the pane, which may be closed by means of a slide if necessary.

2. A pane may be *louvred*, that is, strips of glass lying one over the other and fixed on a frame, which can be opened or shut.

3. A *hit and miss* opening can be made, or a piece of glass made to pull forward and allow air to come in at the sides, as in one of Boyle's ventilators.

4. The upper sash of the window may be let down and the opening filled with wire-gauze.

5. The lower sash may be raised a few inches and a block of wood inserted, so as accurately to fill up the opening. This prevents any direct draught, and provides for an incoming current between the sashes.

6. Slits may be cut between the two sashes, or auger holes pierced, so that a current may enter while the window is shut. These openings may be closed by a kind of lid, or by laying a sand-bag along over them.

Of these plans the most convenient and simplest is No. 5 (suggested by Dr. Hinckes Bird). It can be put in practice anywhere and at hardly any cost. There is generally at least an inch of opening in width between the sashes, so that, with a window 3 feet wide, 36 square inches are at once obtained, or 48 with a 4-foot window. The current of air as it passes in is directed upward and is diffused or spread into the air in such a way that draught is not felt.

Plan No. 6 (as suggested by Mr. Tobin and others) is also good, but I have not found the current quite so constant as in No. 5. In both instances a great deal depends upon the direction of the wind at the time.

II. *Openings at the Floor Line with Upright Tubes.* —These have been brought a good deal into notice within the last year or two. They consist of an opening in the outer wall, usually a grating or ventilating brick; to this is attached a short tube passing into the room and joining an upright tube against the wall. The upright tube is generally 4 or 5 feet high, and may be of various sizes to suit the size of room; it may be circular, semicircular, square, or oblong. There is, of course, loss of power on account of the angle, but the advantages obtained by the arrangement fully counterbalance this; the chief being that the current of air as it enters the room takes an upward direction, which it keeps for some distance before spreading. As it gets near the ceiling it spreads out and mixes generally with the air without producing disagreeable draughts. This kind of tube is often known as Tobin's, but tubes on the same principle are made by various makers, and are to be found in the market under various designations, the principle in all being much the same. Some additions are sometimes made, such as a pan containing water to moisten the air and keep back blacks and dust, or a gauze funnel for a similar purpose; valves or caps are also provided to close them if required in cold weather. There ought always to be means of opening the tubes to get at the inside for purposes of cleaning. A good deal too much has been said about these tubes as giving a constant inward current, but the truth is they are dependent upon the direction of the wind, just like other ventilators. I have proved this by practical examination, finding the current going out by them when the wind blew on the other side of the building. They are, however, very useful ventilators, particularly because they can often be introduced into places where it would be very difficult to get any other kind conveniently applied, and because they certainly prevent draught by the direction given to the current.

III. *Openings in the Walls.*—These are generally either simple gratings, or louvres, or else valve openings. The gratings are not desirable, as they are apt to produce draught, and the louvres are also open to the same objection. Of the other kind the most convenient is the one known as the Sheringham valve. This is an opening in the wall into which air passes, as usual, from the outside through a ventilating brick or grating; on the inside is a piece of iron or wood of a hopper shape, sloping upwards; this prevents the cold air pouring down at once into the room, and directs it up towards the ceiling, whence it flows down gradually, mixing with the air of the room. This ventilator acts as a constant inlet when it is to windward, but it is often an outlet to leeward. It is made of various sizes, and can be closed when necessary.

Another form of inlet (Ellison's) consists of a brick pierced with conical holes. The holes are small on the outside and much wider within; by this means the air is distributed without much draught. It has been well spoken of, although I have no practical experience of it. A considerable number of bricks would be necessary for effectual ventilation.

On the whole, the inlets most suitable are the window opening, as in Plan No. 5, the upright tubes, and the Sheringham valves. Remembering, however, that all are much influenced by the wind, it is well to have them in two walls of the room, opposite if possible, if there should be two external walls, for by such an arrangement we ensure, with tolerable certainty, an inward current on the windward side and an outward current on the leeward, and so effectually clear the room of foul air in either direction.

Inlets for Warm Air.—We have seen that there is a good deal of difficulty in providing sufficient fresh air with cold inlets only, and this is especially the case when the cubic space is small. The only remedy for this is to have some of the incoming air warmed. In houses where there is a regular system of warming by means of hot water or steam, there is no difficulty, as it is easy to pass the incoming air over the pipes or coils to get a sufficient temperature, and the only care then required is to see that the air is not overheated, so as to become unpleasant in smell or too dry. But in ordinary dwellings, when such conveniences do not exist, other means must be resorted to. One of the best and simplest is to have a little space or chamber built behind the fireplace; into this air is brought from the outside through a ventilating brick, and is warmed by the heat of the fire; it then passes, at some convenient opening, either about the chimney-piece or in the upper part of the room, out into the air of the room, thus supplying fresh air and warmth at the same time. To increase the heating power of the grate, gills of iron are placed in the chamber. This is the arrangement in Captain D. Galton's grate, which is so much used in barracks and in hospitals, both military and civil. Another simple and useful form is the cottage grate, devised and recommended by Mr. E. Chadwick, C.B., who has done so much for the spread of sanitary knowledge. When a house is being built the construction of such grates is a simple matter, but if they have to be added afterwards a little more expense is incurred.

When a room is warmed by means of a stove it can be easily supplied with fresh warmed air by having a jacket or covering of metal round the stove, into which fresh air is brought from the outside and delivered thence, warmed, into the room; stoves of this kind are easily to be obtained in the shops. A simple and inexpensive method, with a common stove, is to put up round it a screen or box of wood, open at the top but enclosing the stove except at the front; air may be brought under the floor and pass up through an opening in it round the stove; in this way it is warmed before mixing the air of the room.

Several ingenious plans with gas-stoves have been suggested by which the fresh air is conveyed through a tube warmed by tho gas, or passed over a heated metal surface. Of these the Calorigen of George and the Euthermic stove of Bond are good examples.

Outlets for Foul Air.—Some people have been inclined to insist that we need only provide inlets, and that the outlets will take care of themselves; others say that if there be outlets the air is sure to find its way in somehow. Now, in the former case the outlet would generally be provided by one of the intended inlets taking up that office, and in the latter we might get air perhaps, but it would very likely be from the quarter that was least desirable. The truth is that both inlets and outlets ought to be provided for with equal care. In most instances in ordinary dwellings the only opening is the chimney, and that is commonly boarded up when not in actual use. The consequence is we have smoky chimneys when the fire is lighted, and an offensive atmosphere when the fireplace is boarded up.

The chimney generally provides enough of outlet in an ordinary room, provided there are not too many occupants. Thus a small chimney throat, only 8 inches by 6 inches, will give 48 square inches, sufficient outlet for two persons. If the fire is lighted and there is a proper inlet the ventilation will go on well. A good addition to this, and one that will clear the upper part of the room, is to insert in the chimney breast, and near the ceiling, a Boyle's ventilator. This is a modification of Arnott's, and consists of an iron frame opening into the chimney; across it are iron rods, from which are suspended thin plates of talc. These plates are so fixed that they hang back a little and leave space for foul air to pass from the room into the chimney; when, however, a down-draught takes place they are blown against the frame so as to close the opening and prevent smoke getting into the room. This is a good arrangement for all rooms, and it is a particularly good one for kitchens.

One of the difficulties in dealing with chimneys is the chance of back-draught, but this is due in most cases to the absence of inlets in the room. The fire must have air or it will not burn; if no supply is furnished in any other way it will be drawn down the chimney, and a cold down-current of air may often be felt at the sides of a chimney. If this is not sufficient a sudden down-current occurs, driving the smoke into the room. The only way to cure this is by having a proper inlet, and if anything further is required a cowl can be put upon the chimney, either a *lobster-backed cowl*, turning with the wind, or a fixed one with a double cone, such as Stidder's foul-air extractor.

If gas is used, a special outlet should be provided immediately over the light, either communicating with the chimney or with a separate tube for itself.

Where there are several people occupying a room, it may often be necessary to provide a separate outlet besides the chimney. In top floors an opening through the ceiling may end in a cowl or louvre; and in cottages ventilation may be obtained by openings along the ridge. Where there are Sheringham valves provided these will act partially as outlets, according to the direction of the wind, and will sometimes be sufficient along with the chimney and a Boyle's ventilator.

Flushing with Air.—Whenever it can be done the house should be well flushed with air, by opening windows and doors, so as to allow the air to sweep through. This must not be supposed to take the place of ordinary continuous ventilation, but it is a very important addition, and one that cannot safely be lost sight of.

Warming.—We have already referred to warming, incidentally, when speaking of ventilation, and it has been pointed out how the air may be introduced warmed without very much trouble. The ordinary system of warming by open fireplaces is very wasteful, the greater part of the heat going up the chimneys. A good fire-grate ought either to project well into the room, or to be so constructed that the greater part of the heat shall be reflected into the room. The Galton grate is an example of the former plan, and the plan of Count Rumford the basis of the latter. A fireplace built of fire-clay at the back and sides, with iron bars in front, gives out a good heat, if its shape is a good one. To ensure this let the back of the fireplace be one-third the width of the front, and do not let the depth exceed the width of the back. This shape ensures that all the heat will be reflected into the room, and not to the opposite side of the grate and so up the chimney.

With regard to the actual temperature of rooms a good deal depends upon the way in which they are occupied. Rooms used as mere sitting-rooms, or for sedentary occupations, ought to have a temperature of 60° to 63°; they should not, if possible, exceed 65°. If actual manual labour is going on 60° is quite enough, and even less than this if the work be at all hard. In bedrooms 60° is quite sufficient, and even less than this can be borne with benefit, provided warmth is ensured by means of extra covering. Children and old persons require a rather higher temperature than adults in the prime of life.

Moisture of the Air.—A damp air is justly objected to, but too dry an air is both disagreeable and unwholesome. On this account stoves are sometimes unpleasant, and to prevent the drying effect they have on the air, it is sometimes the practice to have a vessel of water on or near them, which will gradually evaporate and moisten the air. This, however, may be carried too far, so as to produce a steamy condition of the atmosphere. In such a case a vessel of water *in* the room, but not necessarily *on* or *near* the stove, will be sufficient. There is no fear of making the air of a room too moist by admitting even wet outside air, provided the room be of a proper temperature: for moisture is greatly dependent upon temperature, the same amount that would make a cold air damp leaving a warm air quite dry to the senses. But it must be remembered that warmth and moisture are the two conditions which, while they favour the growth of everything, also favour the decay of everything, therefore anything that really tends to make the air damp in a house ought to be avoided as much as possible. On that account cooking, washing and drying of linen or clothes, ought not to go on in a bedroom; sleep is the time for restoring the loss and waste of the day, and therefore everything ought to be in as good and pure a condition as possible, especially the air that is to be breathed.

A source of unhealthiness that is not properly recognised is the damp arising from washing floors. This can be greatly avoided by having floors stained and oiled, or varnished, for then dry scrubbing is generally sufficient, and if washing is really necessary they dry up quickly. If an ordinary deal floor is washed the room ought not to be occupied until it is perfectly dry; this is especially the case with a sleeping-room. The same remarks apply to all woodwork that is not painted, or made in some way proof against wet.

Clearing out of Rooms.—It is a good plan to clear everything out of rooms from time to time in order to cleanse them thoroughly; and in addition to that it is advisable, when possible, to have the rooms unoccupied for a time, so as to enable them to be thoroughly flushed with air, in order to get quite rid of any impurities that may have collected in them. It is not always easy to do this, but it ought to be borne in mind, and advantage taken of any occasion when it may be done, there being no doubt that continuity of occupation is a source of danger to health, and one, too, that is cumulative in its effects. Hence, the advisability of making a *break* in this, and letting the dwelling lie *fallow* for a time. The importance of this in hospitals is now pretty well recognised, and it is carried out whenever it can be done.

Summary of Rules on the subject of Ventilation.—
1. Each person must have sufficient floor-space; in a sleeping-room not less than 42 square feet, as the smallest amount.

2. Each person ought to have as much total (or cubic) space as possible; but the lowest ought not to go below 500 cubic feet, which must be given free of the space taken up by furniture.

3. No room need be higher than 12 feet for health.

4. Additional height must not be allowed to take the place of floor-space; if the height be below 12 feet the floor-space must be increased.

5. Avoid irregularities and dark corners in the room, for these interfere with proper ventilation.

6. See that a room,—especially a sleeping-room,—is not overloaded with furniture.

Have the lightest bedsteads consistent with durability: metal are the best.

Let the space below the bed be left free and open, and do not keep boxes or clothes there.

Avoid curtains and hangings as much as possible; if they are used, let them be of washable material.

Let the floor be stained and varnished or waxed, or covered with kamptulicon, linoleum, or such waterproof material. Carpets should be put down merely in the centre of the room, quite loose, so as to admit of being taken up at any time.

7. The door should fit tightly, so as not to admit the air from the rest of the house.

8. The windows should open freely, both at top and bottom.

9. Inlet opening to the extent of 24 square inches per head should be provided, either by window ventilators, upright tubes, Sheringham valves, or the like.

N.B.—In reckoning this the size of the ventilating brick must be taken. Ordinary bricks yield only about one-third of their gross size as available opening, so that a brick 9 inches by 4 (=36 square inches) would give 12 square inches of *net* opening.

All air should be taken from the outside direct, and not from other rooms, lobbies, or cellars.

10. Outlet opening to the same extent (24 square inches) per head must be provided.

This may be done by the chimney, with the addition of a Boyle's ventilator. In most ordinary rooms this will be sufficient, but it may be necessary to add to the opening in special circumstances.

An outlet over gas-lights ought to be provided.

11. Ventilators should always be kept open; except in very cold weather, when the air brought in ought to be partially warmed.

12. A fair temperature, but not too high, should be kept up: never exceeding 65° F.; in most cases 60° F. is quite enough.

13. The air should be moderately dry: if there is a wet and dry bulb thermometer in use the difference between the two should be 4° or 5°.

14. All rooms should be freely flushed with air as often as possible,—by opening windows and doors wide.

15. All rooms should be emptied, cleaned, and left unoccupied for some time periodically.

16. When floors, woodwork, &c. are washed that take some time to dry, the rooms should not be occupied until they are quite dry.

Keeping of Food.—This is an important point. All larders or store-rooms ought to have a north aspect and to be freely ventilated. Food, especially meat, fish, and milk, ought to be as much removed as possible from anything that could render it impure. Milk appears especially liable to take up organic impurity, and perhaps to carry disease more readily than some other things. Larders or store-rooms ought to be quite away from the influence of drains, water-closets, privies, dust-heaps, and the like. Yet it is not unfrequent to find them placed alongside or immediately under a water-closet, with a soil-pipe, not always water-tight, passing down inside before it goes out to join the drain.

Food ought not to be kept in any room continuously occupied, and never in a sleeping-room, or in cupboards off it. Nor ought it to be kept near sinks or places where slops are commonly emptied.

If those precautions are neglected it will be found that meat and fish are apt to get tainted and milk to get sour, besides running the risk of becoming the vehicle of some form of disease.

CHAPTER VII.

THE HOUSE IN SICKNESS.

THE precautions necessary for health, which have been already enumerated, are doubly necessary when there is sickness in the house. Even with every precaution, it is hardly possible to prevent sickness, although by far the greatest part of the illness that we meet with is preventable. By attending to proper rules of living we may avoid much of it, and by proper care when it does come we may moderate its severity, prevent its spread, and hasten the recovery of the patient. It is a truth which every wise physician recognises, that medicine can do but little if it is not assisted by nursing and hygiene (or the rules of health), and many a case, which would be quite within the power of the doctor to lead to a favourable end, goes wrong for want of the constant attention so necessary in every case of illness. I shall here say a few words with reference to the precautions required in so far as the habitation is concerned.

It must be understood that ventilation is one of the prime essentials. When a person is ill a very much larger amount of impurity is given off from his body, and it is of a more dangerous character. In the various experiments I have made, with reference to sick people, I have found that a much smaller amount of impurity from the bodies of the sick is perceived by the sense of smell than is the case with healthy persons. One reason may be, that a sick person is generally a longer time in his room continuously, but this is not all the reason. The proportion is very nearly as four to three, and therefore cases of even ordinary illness ought to be supplied with about *one-third* more air than persons in health. Now, if 3,000 cubic feet per hour be the standard in health, at least 4,000 should be given in ordinary sickness. In cases of severe sickness, such as fevers and the like, the amount of fresh air ought to be practically unlimited. It is a common idea that, in illness, it is dangerous to open windows for fear of catching cold, but this is an error; if the patient is well provided with covering there is little fear of catching cold in bed. Care should be taken to keep the temperature up by ordinary methods of warming, but if heat or fresh air has to be sacrificed, it is in most cases better to let the temperature rather go down than the air be foul. Although this is applicable in a general way to all diseases, it is especially so to the class of infectious or contagious diseases, as nothing is so powerful an agent against their poison as plenty of fresh air. In most cases infection only acts where the dose of poison is strong and concentrated, but if it be well and *immediately* diluted, the danger of spreading is very greatly reduced. It is also of the greatest benefit to the patient, for nothing retards convalescence more than the continued re-breathing of disease poison as it is thrown off into the air; whilst nothing renders convalescence so rapid as a copious supply of pure air.

In cases of serious disease, one of the first things to be done is to clear the room of bulky or superfluous furniture as much as possible, or to place the patient in a room already cleared. An open bedstead, without curtains or valance, and with no covering that is not washable, is the best kind of bed. It ought to stand out into the room, so that it is possible to get freely at both sides and all round it; the space below the bed ought to be perfectly clear, and without carpet of any sort. The attendants ought to wear dresses of washing material and of a light colour, so that soiling may be easily recognised.

No food or medicament ought to be prepared in the patient's room itself, if it can possibly be avoided; this is to prevent undue moisture, smell, or organic or suspended matter getting into the air.

There must be no washing of floors, &c., during occupation of the room.

Clothes and bedding should be aired in an adjoining apartment, and not in the patient's room.

When a bedpan or close-stool is used, the excreta should be received into some disinfectant, and more ought to be immediately added after use, before the utensil is removed. If the disease is not an infectious one the stool may be sent down the closet, but if it be infectious, it ought to be taken away and buried at a distance from any well.

PRECAUTIONS IN PARTICULAR DISEASES.

1. *Scarlet Fever.*—This is one of the most contagious diseases known, and also one of the most dangerous. The first thing, therefore, to attend to is *isolation*, that is, separation of the patient and his attendants from the rest of the inmates. Some people have a notion that there are a certain number of diseases that people must pass through, and that therefore if a disease is in a house it is as well to let it go through the family, as it will save them taking it afterwards. Now it is quite true that there are diseases which people very seldom take twice, so that

one attack protects them from another, but to reckon upon this would be very unsafe, for several reasons. In the first place the protection is not absolutely certain: I have known patients have scarlet fever twice and even three times, and also cases of second attacks of typhus fever, which is a disease seldom taken more than once. Another error arises from the idea that there is a mild form of the disease essentially different from the more severe, and a difference is made between *scarlatina* and *scarlet fever*. Now this is quite wrong,—the former being merely the technical or Latin word for the latter. They are the same disease and require the same precautions; but, trusting to the supposed existence of a mild form that will protect from the more severe, it is sometimes thought advisable to encourage its spread in a house. It ought, however, to be known, that, although mild cases do occur which may be protective, we never can tell whether a case is likely to be mild or severe,—and the danger even of a mild case is not inconsiderable, as it leaves traces long after it which may lead to serious consequences. Another reason for combating such views is that with every additional case an additional centre of poison is created and the danger of spread increased. It is like the old system of inoculation for small-pox, which is now rendered penal by law. It is true that it did to a certain extent protect some people by inducing a mild attack of the disease, but it also sometimes killed and it greatly increased the danger to the community at large. Vaccination on the other hand introduced a form of disease of a character quite different in its working, for while it protected from the dangerous and loathsome small-pox, it did not injure the patient, and it spread no dangerous poison around.

The truth is, that, as regards ordinary infantile diseases,' like scarlet fever and others, there is no absolute necessity why people should take them. Many people pass through life without doing so, and the more that do so the better; for it is quite a mistake to think that their danger is over with the convalescence from the actual disease: on the contrary, in many cases they leave behind them remains which show their effects sooner or later, either in derangement of important organs or by laying the patient open to attacks from other disorders. It is therefore best to try and isolate the cases as much as possible, by placing them in rooms as much separated as may be from the rest of the house, and keeping the rooms bare of all but the necessary furniture, bedding, &c. Oiling the body carefully over is a good precaution, as the chief poison is in the scales which come off the body in such quantities, during the *peeling* which takes place in convalescence. In a house where a room well apart cannot be provided a good plan is to hang a sheet before the door, which may be kept moistened with a disinfectant. All clothing and bedding should be plunged into disinfecting liquid and carried away to be boiled at once, or passed through a disinfecting chamber, if one is available. It is unfortunately seldom that such a chamber is available, but thorough boiling for a long time will be in most cases quite effectual. Articles of small value ought to be burnt at once. When the case has terminated, and the patient has either died or is convalescent and has left the room, steps should be taken to purify it. The bedding ought to be removed, boiled, steamed or heated to a temperature at or above the boiling point of water; the mattresses should be sent to a disinfecting chamber if possible, or if that is not available they ought to be taken to pieces, the ticking boiled, and the stuffing, if it be of value, such as hair, exposed freely to the air for a long time. The walls and ceilings ought to be thoroughly scraped, every particle of paper being removed, and the room ought to be fumigated,—sulphur being the most convenient. The room ought to be closed completely, and a pipkin with some hot cinders or charcoal left in it on which sulphur has been well sprinkled. Of course no one must remain in the room, as the gas, to be at all efficacious, must be so strong as would be fatal to the life of any being present in it. Not less than 1 lb. of sulphur is necessary for every 1,000 cubic feet of space, and indeed more would probably be required for complete fumigation. After some hours the room may be opened and freely flushed with air for a good while. It may then be washed with soft soap and carbolic acid, and the ceilings whitewashed with lime and carbolic acid. It is better to do the same to the walls and to leave them for a time,—but if they are papered the addition of carbolic acid to the paste may be a wise precaution.

2. *Measles.*—As this is an eruptive disease of a similar kind the same precautions would be applicable. Its poison is, however, much more easily carried about, so that it is not so easy to prevent its spread.

3. *Small-pox.* — This very loathsome disease is fortunately much rarer than in former times, but we have outbreaks of it from time to time, probably due in a large measure to lax administration of the law enforcing vaccination, and to the mistaken opposition to it, fostered by an obstinate class of people. Here, besides complete isolation of the patient, we have the obvious indication to re-vaccinate at once every person in the house, or who is likely to come near the patient. If the vaccination does not take no harm is done; if it takes it shows the necessity for the operation.

The precautions for purification must be not less complete than those for scarlet fever: bedding, &c., must be thoroughly disinfected, the room must be cleansed and fumigated with every care, whilst small articles, such as toys used by children, books and articles of little value, had better be burnt at once.

4. *Diphtheria.*—Unless this disease can be traced to direct infection it may be safely laid down that the drainage of the house is defective. One of the most important steps to be taken is the immediate evacuation of the house, and the removal of both the patient and the other inmates to another locality—a tent or shed being safer than remaining in the house under those circumstances. As soon as this is done plenty of a strong solution of carbolic acid ought to be sent down the drains, and the closets and drainage system ought to be thoroughly examined. In almost every case some flaw will be detected; steps can then be taken to thoroughly disconnect all the drains from the house, as before recommended, and to remove all soil-pipes outside the building.

The poison in this disease exists in the discharge from the throat chiefly; it is very subtle, and terribly contagious. All the precautions already mentioned are necessary, except the oiling of the body, which is only applicable when the skin is the chief source of poison.

In this disease it is advisable to use small pieces of calico to wipe the mouth and nostrils, and to burn them at once. Expectoration ought to be received into a vessel with disinfectants, as ought also the stools, and all should be burned.

The purifying of the house ought to be carried out most completely before re-occupation.

5. *Typhoid Fever.*—This disease, now often called

enteric fever—a better name as not leading to confusion with other diseases—is one of the severest scourges of civilised life. For a long time it was comfounded with *typhus fever*, a disease which resembles it in some particulars, but it is quite different in its origin and in many important characters. *Typhoid* fever is especially characterised by disease of a certain part of the bowels; it is often—but not always—accompanied with diarrhœa or looseness, and death sometimes occurs from loss of blood by the bowels, or from the bowel itself being eaten through by the disease. It is a disease that lasts several weeks, and is very subject to relapses. It attacks the young especially, but no age can be considered quite safe from it, although cases above the age of forty are rare,—probably because the particular glands in the bowels, which are the seat of the disease, commence to disappear in later life. So far as we know the disease is propagated by means of the stools of patients suffering from it, either by particles getting into the air and being breathed, or into the water and being drunk; or even sometimes into articles of food, and being swallowed. It appears to arise most frequently: 1st, from the air of sewers or cesspools into which typhoid stools have passed; or, 2nd, from drinking water, which has been contaminated with those stools. The evidence on this point is very strong, and there appears to be but little proof that the disease is infectious or contagious in any other way. How long stools will retain their contagious property is very uncertain, but there is likelihood that the time is very long; and indeed it is not improbable that ill-flushed sewers and drains may hold it in an active state for a very considerable time. There are no places free from it, but it is propagated most freely where there is communication between one house and another, either through the drains or the water-supply. Thus, in places where several houses drain into one cesspit, or in towns where there is an imperfect system of drainage, the disease will often spread rapidly, because the cesspit or drains are not ventilated, and because there is not efficient disconnection between the houses and the drains. Also sewage containing typhoid stools may pass into the wells or into the streams from which the water-supply is drawn; or again, the water-pipes of a general supply on the intermittent system may suck foul gases, or even liquid and solid sewage, out of closets, and so propagate the disease among the consumers of the water.

Bearing those points in mind the precautions to be used are obvious, and have been already detailed in previous chapters. I may, however, shortly repeat them:

1. Take care that all *soil-pipes*, *sink-pipes*, *waste-pipes* or *discharge-pipes* of any kind, are thoroughly and completely disconnected, so as to render impossible any access of sewer-gas to the house.

2. See that the water-closets have a distinct and separate water-supply from that used for drinking purposes, and make such arrangements as shall render it impossible that the one supply can be used for the purposes of the other.

3. If you have any reason to suspect the drinking-water, take care to have it thoroughly boiled before use: it may also be filtered, but boiling is a more certain safeguard.

As milk is also believed to have been a means of propagation, it ought also to be boiled in cases of suspicion.

With such precautions as these it is hardly possible that the disease could be contracted, except *outside* the house; but, of course, however careful one may be oneself, it is impossible to guarantee equal care on the part of one's neighbour.

Suppose, however, that a case is introduced into the house, what precautions should we take? The chief general precautions in a sick-room should, of course, be adopted, but the main care must be directed to dealing with the stools of the patient. The chief object must be either to prevent the stools passing into the ordinary drainage system or to render them harmless before they do. In a town it is hardly possible to do otherwise than let them pass into the drains, however undesirable it may be; therefore all we can do is to neutralize the poison as much as possible. For this purpose strong disinfectants should be used,—a little being placed in the bedpan or close-stool before use, and more being added immediately after. In the country the better plan is to disinfect them strongly as above and then to bury them at a good distance from any water supply: earth is an excellent disinfectant, perhaps the best when properly applied.

The attendants must be particularly careful about the soiled linen, &c., which ought to be at once placed in a vessel of water with strong disinfectants and then thoroughly boiled before being washed. They should also be very careful about washing their own hands and personal clothing that may become soiled, particularly before partaking of food and drink themselves, as there is good reason to believe that the disease has been contracted through carelessness in this matter.

After the convalescence of the patient the room ought to be thoroughly cleansed and well aired, but there is no call for the more extreme measures of purification which are necessary after small-pox and scarlet fever.

6. *Cholera.*—This terrible disease, happily only a rare visitor in most parts of the world, has much resemblance to typhoid or enteric fever in the way that

it is propagated. The disease poison appears to exist chiefly in the evacuations, but, as these are greatly more copious and watery than those of typhoid fever, and as they are both vomited and passed by the bowels, it follows that the possibility of the spread of the disease is thus increased. Every precaution that would be taken in the one disease must be adopted with increased care in the other. Like typhoid fever it appears to be but little contagious, except through the evacuations. After the termination of the case very great care in cleansing out the room ought to be taken, the colourless watery character of the evacuations rendering it difficult to detect where they have, and where they have not, descended.

7. *Typhus Fever.*—This disease used to be much more common formerly than it is now, but still it makes its re-appearance from time to time. Like the plague it is essentially a disease of filth, crowding, and destitution, but once established it is capable of being communicated to others than the poor and wretched. It is the disease of famine, although not the same as the so-called *famine fever*, which is a painful but less deadly malady; but it accompanies or follows the famine fever in most instances. The true famine or relapsing fever has been called the fever of starvation, whilst typhus requires crowding and filth, in addition to starvation, to develop it. Typhus is generally a disease of winter, as the cold increases the amount of crowding and consequent foul air. It is also the spotted or putrid fever of jails, and the terrible scourge of armies, where it is often combined with scurvy, in which case it is extremely fatal. As a proof of this I may cite the ravages it committed in our own and other armies during the great wars in the beginning of the century,—to our own sad experiences and those of our allies and adversaries in the Crimea and Turkey

during the Crimean War,—and to the terrible losses in the late Russo-Turkish War. The best precautions against this disease are: the greatest cleanliness of house, clothing, and person, and plenty of fresh air.

Should the disease actually break out the strictest attention should be paid to ventilation, even at the sacrifice of warmth if necessary. If the house is overcrowded the inmates must be removed and more widely scattered. Nothing arrests the disease so much as the complete *scattering* of the population over a large area. The disease itself is much more contagious than typhoid fever, or even cholera, the poison being given off from all parts of the body and passing into the air. The stools are not particularly dangerous, but still precautions ought to be taken.

After the case has terminated the greatest care must be taken to purify the room,—precautions similar to those directed for scarlet fever, for the two diseases are not unlike in their mode of propagation.

The House in Childbed.—Perhaps in no case are the rules of hygiene more necessary than when we have to do with a case of childbirth; whether we have regard to the tenderness of the infant or the serious danger to the mother. It is apparently one of the drawbacks of civilized life that it seems to increase these dangers very considerably, and it is a fact which is on a par with some of the other facts we have mentioned, that in many instances the very measures adopted for the care of this class of cases have proved the most fatal. This is especially the truth when a number of women are collected together, as in lying-in hospitals; for the aggregation of cases of this sort must be looked upon as a danger not dissimilar to the collecting of a large number of severe surgical cases, and therefore the steps for the assuring of every hygienic precaution ought to be most especially provided for. In too many instances this has not been understood, and disastrous results have followed. We are not now concerned with cases massed together, but with single cases, occurring in ordinary dwellings.

One of the commonest notions is that the great danger to both mother and infant is from cold draughts of air, and to avoid these both doors and windows are kept scrupulously closed. Now, here, as in many other circumstances already referred to, the first thing needful is *fresh air*, and plenty of it. A chilling temperature is very undesirable, but foul air is ten times more dangerous. Additional warmth can easily be supplied by additional covering, and temperature had better be sacrificed rather than fresh air. A deficiency of air retards the due changes which tend to re-establish the healthy condition of the mother, and allows impurities to circulate in her blood, which it is of vital importance that she should get rid of as rapidly as possible. Also, as regards the infant, fresh air is equally necessary, otherwise the child sickens—is tormented with flatulence and pain, and both loses its own rest and breaks that of the mother. Air, therefore, ought to be supplied copiously, in quantity double that required in health.

The most scrupulous cleanliness is also necessary, as well as the immediate removal of all sources of impurity from the neighbourhood of the mother and child.

In these cases the influence of sewer-air is most marked and most disastrous, and therefore every care must be used to prevent its access to the house. Child-bearing women must be looked upon in the same light as severe surgical cases, which are always aggravated by any form of foul air, and especially by the air of closets, middens, cesspits, and sewers.

It should always be borne in mind that the fatal group of complaints, known as *puerperal*, or childbed fever, may arise in any lying-in woman, without its being necessary that infection should have been caught from any previous case; in fact this disease may arise on account of the absorption of any putrefactive poison; hence the importance of preventing the possibility of any such poison reaching the patient. Disinfectants may here be used with advantage, such as Condy's fluid, sanitas, the terebene preparations, and carbolic acid, unless the smell is objected to.

As regards the infant it must be remembered that children are peculiarly susceptible to external influences, and are quickly affected by any poison in the atmosphere. Probably a large share of the great infant mortality in the earliest days of life is due to the foul air in which the poor things are kept.

Another thing that should not be lost sight of is this, that the danger does not cease with the mere short term of lying-in, for, by inattention to proper hygienic rules, the mother may receive a shock to the system that will show itself hereafter, not only in ordinary ways, but also in a weakened offspring, and a more doubtful recovery from future confinements; whilst, in the case of the child, the seeds of disease may be sown, which may bear bitter fruit in himself in after years, and in his descendants in later generations.

This is a solemn consideration, which, while it must underlie everything that appertains to the care of health under any circumstances whatsoever, ought to impress us most especially in dealing with young infants: their small frames are eminently plastic and easily take impressions for good or for evil, and these impressions they may transmit to generations afterwards; so that we really hold the future of a nation, or even of the human race itself, in our hands. The responsibility is great if we fail in our duty through ignorance, but how infinitely greater if we fail to apply the knowledge we may possess, through mere indolence or carelessness.

s.—I have referred several times to

disinfectants, and I think it would be well to say a few words about them specially. The whole question of disinfection is a very difficult one, and one about which there has been great dispute. To discuss the grounds of dispute would serve no good purpose here, but there are some points on which a little cautionary advice may be given.

In the first place, the word *disinfection* is apt to mislead, because it gives the notion that the process so termed actually destroys or neutralises *infection.* Now, there is only one process to which this term can with true accuracy be applied, and that is, *heat* raised to a considerable height, viz., up to and beyond the temperature of boiling water. This, if properly applied, will, I believe, infallibly destroy disease poison of every kind. There are two ways of applying it, by moist and by dry heat—that is, by boiling or by heated air; we might add a third—by steam under pressure, which is also efficacious. I think thorough boiling would be effectual in nearly all, if not in all, cases, and is the most easily applied to clothing, &c. The other forms of heat require special apparatus, and if not properly regulated, are injurious to the fabrics. The best at present in use is the gas-stove of Ransome, now used in a great many public institutions. It would be highly desirable that there should be one, available for general use, in every district, for it is obvious that there are some things which cannot easily be boiled, such as beds, &c.

Of other so-called *disinfectants* the greater number are little more than *deodorants,* that is, they destroy or mask smell with more or less success. It is only when they are powerfully corrosive and positively poisonous that they are efficacious, and even then they require to be used in very much larger quantity than people generally have any notion of. Thus gaseous disinfectants, like sulphurous or nitrous acids and chlorine, must be used so as to make the atmosphere for the time fatal to all life. Any amount that could be borne by human beings only makes a suffocating smell, without in all probability affecting the particles we wish to destroy. With regard to solid and liquid disinfectants, we may say that those which are really efficacious in *destroying* disease poison are highly dangerous, whilst those that are not dangerous have but little power. A great many, however, are useful in counteracting smell, either by chemical action, such as chloride of lime, Condy's fluid, salts of iron, &c., or by masking it, such as carbolic acid, terebene, &c. We must be cautious how we depend upon disinfectants acting really as such, for the mere *deodorant* effect is by no means the same thing; the action of chemical deodorants is strictly limited by their amount and the relation they have to the substances attacked, whilst the masking deodorants are generally volatile and let loose the original odour when they have more or less completely evaporated. The most powerful substances are chloride of lime and cupralum; these appear to exercise considerable destructive power when added in quantity. Of those which *mask* smell and *suspend* action there are several, such as carbolic acid in its various forms, and the terebene compounds. Some substances, such as the liquid called *sanitas*, are stated to have destructive effects as well as mere *masking* properties, and the substance just mentioned has also the advantage of being capable of mixture with water in almost any strength. Both it and the terebene preparations have pleasant odours, whereas many people object to the smell of carbolic acid.

If we seek actually to destroy disease-poison we can hardly depend upon any of those substances except perhaps chloride of lime and cupralum, but many of the others are useful as *suspending*, for a time at least, the virulent activity of the infection. We can, accordingly, make use of this property advantageously, as in the case of a typhoid stool, to which we can add some disinfectant which will arrest or suspend its dangerous action until we can dispose of it.

The practice, however, of throwing indiscriminately solid disinfectant powders down closets is not one to be commended, for it does little real good and often clogs the drains.

The truth is, we must look upon disinfectants as an *assistance*, not as a *support;* they are useful in certain cases and under certain conditions, but our main reliance must be upon the more general principles of health; upon the supply of fresh air and pure water; upon a rational arrangement of our house; upon proper conservancy; on complete disconnection of our soil, sink, and waste pipes, &c.; and upon scrupulous cleanliness of house, clothing, person, and utensils. Were all those points really attended to disinfectants would be but little wanted.

CONCLUSION.

It has often been said that the life of man is a perpetual struggle with the forces of Nature; that the continual effort is to oppose the tendency to decay and disintegration which is the fate of all organized beings. The struggle may be more or less protracted, but the end is the same, for the time surely comes when the repeated attacks exhaust the strength of the garrison, and the fortress must surrender. During this long contest there are a hundred ambushes prepared, into one or other of which we may fall at any moment. Such a view is so far a true one, but yet it is not all the truth; it is true that the forces of

Nature fight against us, but it is also true that it is by them and through them that we move and have our being, whilst it is not less true that the worst pitfalls that endanger our path are those we dig ourselves. We have seen in the foregoing pages that a large number of the diseases which afflict mankind are due to our own neglect and to the obstruction that we offer to the forces of Nature. Nature gives us pure water, and we defile it with our own sewage; when she offers us a pure soil we speedily render it unfit for living on. Pure air is in abundance all around us, but our chief effort appears to be to keep it out of our dwellings and to re-breathe the polluted atmosphere we so carefully cherish within them. The great circulation of Nature provides means for disposing of our waste material by applying it to the growth of crops, whilst we recklessly cast it away to pollute our soil unproductively, to defile our wells, lakes, and rivers, and even to render the sea itself filthy. It is only by a clear recognition of the errors we commit on these points that a reformation can be effected, and the general tone of health be raised, and the death-rate diminished. Much has been done of late years by legislation, and much more may still be done; but it is obvious that legislation cannot do everything, and that, in particular, it cannot much affect those points of private and domestic hygiene which must be the care of the householder himself. In places of a more or less public character the authorities can interfere, such as in schools, common lodging-houses, hospitals, barracks, prisons, and the like, but with the dwellings of the vast majority of the people it can only deal in a very partial manner. Even if it were advisable or desirable that there should be more interference, the results of it would probably be very unsatisfactory, for no improvement of any permanent kind can be expected unless the members of the community themselves are convinced of the necessity of the improvement. Thus, it may be all very well to put ventilators into a house, but if the inmates are not convinced of the necessity for fresh air the chances are that they will be closed up, and no amount of inspection could prevent this. Similarly pure water may be provided, but many people will resort to impure, either because it has a more sparkling taste or from sheer force of habit. Here, however, we may step in and stop the suspicious supply, but we cannot stop the supply of foul air, which is the most fertile of all causes of disease. It is therefore of the highest importance that the essentials of health should not only be enunciated, but that they should also be "understanded of the people." For this reason I have gone into the *reasons* of the different rules laid down in some detail, in the hope of making those reasons sufficiently clear to induce the adoption of the rules. Many of them are no doubt fraught with difficulty, especially in the dwellings of the poor, but in most of them it is really only the first step that costs, whilst a practice once commenced very soon becomes a habit, the irksomeness of which is no more felt than the act of breathing. Let us remember that strict attention to the laws of health is a duty not less grave than any other which may be at present more acknowledged, and that it is an advantage as well, for it both increases our capabilities for useful work and our capacity for the enjoyment of life; so that the Greek poet was not wrong when he spoke of health as the "eldest-born of the blest."

THE END.

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