resinous nature; and is therefore quite soluble in alcohol, essential oils, and alkaline lyes; but sparingly in boiling water, and hardly, if at all, in cold water. The colouring matter which is obtained by evaporating the alcoholic infusion to dryness, has been called *santaline;* it is a red resin, which is fusible at 212° F. It may also be obtained by digesting the rasped sandal wood in water of ammonia, and afterwards saturating the ammonia with an acid. The *santaline* falls, and the supernatant liquor, which is yellow by transmitted, appears blue by reflected light. Its spirituous solution affords a fine purple precipitate with the protochloride of tin, and a violet one with the salts of lead. Santaline is very soluble in acetic acid, and the solution forms permanent stains upon the skin.

Sandal wood is used in India, along with one-tenth of *sapan* wood (the *Cæsalpinia sapan* of Japan, Java, Siam, Celebes, and the Philippine isles), principally for dyeing silk and cotton. Trommsdorf dyed wool, cotton, and linen a carmine hue by dipping them alternately in an alkaline solution of the sandal wood, and in an acidulous bath. Bancroft obtained a fast and brilliant reddish-yellow, by preparing wool with an alum and tartar bath, and then passing it through a boiling bath of sandal wood and sumach.

According to Togler, wool, silk, cotton, and linen mordanted with a salt of tin, and dipped in a cold alcoholic tincture of the wood, became of a superb ponceau-red colour. With alum they took a scarlet-red; with sulphate of iron a deep violet or brown-red. Unfortunately, those dyes do not resist the influence of light.

SANDERS WOOD. See SANDAL WOOD.

SANDARACH, or JUNIPER RESIN, is a peculiar resinous substance, the product of the *Thuya articulata*, a small tree of the coniferous family, which grows in the northern parts of Africa, especially round Mount Atlas. It is imported from Mogadore.

The resin comes to us in pale yellow, transparent, brittle, small tears, of a spherical or cylindrical shape. It has a faint aromatic smell, does not soften, but breaks between the teeth, fuses readily with heat, and has a specific gravity of from 1·05 to 1·09. It contains three different resins; one soluble in spirits of wine, somewhat resembling *pinic acid* (see TURPENTINE); one not soluble in that menstruum; and a third, soluble only in alcohol of 90 per cent. It is used as pounce-powder for strewing over paper erasures, as incense, and in varnishes.

Sandarach is softer and less brilliant than shell-lac, but much lighter in colour; it is therefore used for making a pale varnish for light coloured woods. See VARNISHES.

SANITARY ECONOMY. This term is used to express and to include everything which is done or can be done towards the preservation of health, but in its more restricted and usual sense it is the method of preserving the health of communities. It therefore interests the largest communities, such as nations, and the smallest, such as families, whilst of necessity the interest of the individual is not forgotten; and there is a point at which it merges into medicine or medical economy. It is sometimes called sanitary science, but it is not well to be very lavish of the word *science*, which, although originally only knowledge, is now better confined to cases in which nature herself has pointed out a definite system of laws. Now all the facts brought into prominence by sanitary economy are more or less connected with some science the laws of which are investigated in other relations; but so wonderfully does nature act, that isolated facts from all the sciences frequently come out and form a series so connected, that for a time the judgment is in favour of believing that they may be so arranged as to form a true science; and in some cases this is an open question. Many sciences, perhaps every science, assists in the art of true sanitary economy. Its necessity has arisen from that class of misfortunes to which man has been subject affecting his health; or, as some would say, from certain defects of nature which man is required to supplement. Many of these defects are told in a long series of the greatest miseries; some in a long series of more limited but constant sorrows; and others have been sufficiently small to be considered rather as annoyances. In "Bascombe's History of Epidemic Pestilences" we may read of many hundreds that have attacked man in every known country, and, we may almost add, in every age. In the East we have frequent mention of plagues.

Plagues have frequently followed the track of great, and especially of defeated armies, as well as taken refuge in beleaguered cities.

Hecker's "Epidemics of the Middle Ages" shows few years in which some part of the world has not been suffering under an epidemic. In our own times cholera has long been known to be seldom quite extinct. As an instance of the mode in which these epidemics travel, let us follow the track of cholera. It first appeared at Jessore, on the Delta of the Ganges, reached Jaulnah and Java, and the Burmese Empire in 1818; Bombay, in August of the same year, Arracan and Malacca: in 1819, Penang in Sumatra, Siam, Ceylon, Mauritius, and Bourbon; in 1820, in Tonquin, Cambogia, Cochin-China, South China, Philippines; in 1821, Java, Bantam, Madura, Borneo, &c., Muscat in Arabia, and Persian shores; in 1822–23–24, Tonquin, Pekin, Central and North China, Moluccas, Amboyna, Macassar, Assam; in 1822–23, Persia, Mesopotamia, Judæa; in 1823, Astrachan, part of Russia; in 1827, Chinese Tartary — in all these countries committing ravages hitherto unheard of. In 1830 it went back to Russia, to Poland, Moldavia, and Austria. In 1831 it appeared in Riga and Dantzic, Petersburg, Berlin, Vienna, Sunderland, Leith, and Calais; in 1832, in London; 1834, Spain, the Mediterranean, and North America. In Arabia, one-third in the chief towns died; in Persia, one-sixth; in Mesopotamia, one-fourth; in a province of Caucasus, 10,000 died out of 16,000; in a province of Russia, 31,000 out of 54,000. Plagues are, therefore, still capable of exercising a fatal influence equal to that of the most ancient times. In European towns generally the greatest number of deaths was found to be in the districts least provided with means of cleanliness. It was found among the poor and ill-fed, among the dark races, and the grades of lowest constitutional power. (*Copland's Dictionary: — Pestilence.*) It is also to be remarked, that in all the places where cholera was most violent, civilisation had not attained its European maximum. Cholera is an attack of the chemical forces on the vital forces; vital force even in the form of moral confidence repels it to a great extent, as it does other infectious diseases; but, for the same reason, fatigue and depression of mind hasten the action. The ordinary chemical forces act in the viscera instead of the chemico-vital. The lungs are gorged with blood, unable to send it away oxidised; the gall increases because carbon is not burnt, and urea is not secreted as there is no normal decomposition of the food. Vital force therefore fails, and a kind of putrefaction or fermenting action begins. This is only one instance of the many evils that have followed man. This is not the place to speak of black death, sweating sickness, and the other diseases, down to milder influenzas, which are continually infesting some of our race.

Diseases of this kind are believed to be caused by decomposing matter; they seem to rise from fœtid cities or fœtid land. Deltas have been chiefly blamed; that of the Ganges for cholera, that of the Nile for plague, that of the Mississippi for yellow fever. Although from this view diseases would be considered as under the power of mankind to suppress, their cause seems too widely diffused to place them under the direct control of limited communities, much less of individuals.

About 1350 the whole world was thrown into violent commotion. The change may be said to have begun in 1333, when floods, earthquakes, and sinking mountains are spoken of as occurring in China. Plague and parching drought covered much of the East: Cyprus was nearly destroyed. In that island the earth opened and sent out a fœtid vapour which killed many. A mist, thick and putrid, came to Italy from the East. Earthquakes occurred all along the Mediterranean. Noxious vapours and chasms seem to have extended hundreds of miles. (*Hecker.*) Diseases from these causes are of course out of our control.

Another natural source of disease is the existence of marsh land, producing malaria. Malaria may also be produced from woody land and moist land, especially if there be many impurities. Deltas, or low lands, at the mouths of rivers, land flooded either by salt or by fresh water, especially if alternately by one and the other, not forgetting the great alluvial deposits, which are kept moist in hot climates. Numerous as are the cases of malaria where it is difficult to see the cause, the connection of the marshes with some febrile diseases is beyond any question. The fevers from this source seem in their worst states to pass into yellow fever. This class of fevers is not epidemic, and does not travel far from its source. There are of course many cases of its being carried by the winds to a great distance, and the distance seems to depend on the amount of marshy land, or, in other words, on the extent of the poison produced. If little exist, it is dispersed before the wind travels far.

Conditions of the weather may cause vegetation to putrefy instead of growing. In 1690, a striking example of this occurred at Modena, although other examples might be taken much nearer if there were not such multitudes of opinions upon them. Four or five years of unusual dryness had occurred; fruit was abundant, however, and health satisfactory. A wet winter came, cloudy and calm, without cold. This state continued through summer, with much rain. The numerous and noisy grasshoppers of Italy almost ceased, and frogs, that belong to a country of marshes, took their place. The corn had ceased to grow, and its place was supplied by fishes, so abundant was the water on the land; whilst also organic matter was driven into the streams in unusual quantities. Vegetation was attacked with *rubigo*,—a rusty withered appearance,—which increased in spite of all precaution; beginning with the mulberry, it attacked the corn, and then the legumens, and especially the beans. This extended over the higher spots as well as the lower. It was melancholy to look on the fields, which, instead of being green and healthy, were everywhere black and sooty. "The very animals returned the food which they had eaten. . . . . The sheep and the silkworms perished. . . . . The bees made their honey with timidity. . . . . The waters became corrupt, and fevers attacked the inhabitants, chiefly the country people, such as lived on the wet lands. This state produced intermittent fevers."—*Bern. Ramazzini.*

Again, there are causes purely artificial arising from the state of our towns in manufacturing districts.

It has been proved that diseases may be produced artificially of a kind closely resembling the great world epidemics. When persons live closely crowded together health gradually begins to fail, and loathsome diseases rapidly grow. These diseases vary immeasurably, and the variation seems to be as great as the modes of decomposition of animal matter. After a time these diseases attain virulence sufficient to be infectious or contagious through the atmosphere.

These various conditions are not perfectly understood, but even the statement of our ascertained knowledge has been most widely misunderstood by the public, and sometimes even by professional men, many of whom, if they have conceived the matter clearly, have not expressed it well.

There are at least three principal methods by which the air is rendered impure. 1st. By noxious gases, dust, and ashes, produced by geological, atmospheric, or artificial causes, sulphurous gas, carbonic acid, sulphuretted hydrogen, and perhaps many others. 2. Epidemic or travelling causes to all appearance reproducing themselves as they advance, as in plague and cholera. Similar diseases produced by artificial or neglected accumulations of filth. 3. Malaria, or diseases caused by the disturbed or badly-regulated relation between the soil and the atmospheric conditions, whether from natural or artificial causes. It would be difficult to include all the various evils arising from too much heat, cold, &c. &c.; knowing these things, we are able to a considerable extent to guide ourselves. When the disease or nuisance is caused by processes of manufacture the law sanctions interference. The judicious management of this branch of the subject is of the greatest importance to the community.

There are also causes of disease relating more to the condition of the atmosphere; for example, from the prolongation of a current of air or wind from one particular district, without due mixture; and from conditions of moisture, and of electricity.

Sanitary economy devises a method of avoiding the diseases spoken of. As to the first, those produced by geological phenomena, our chief protection lies in the choice of place: this remark may also apply to those diseases produced by atmospheric stagnation and electrical condition. All we can do is to choose places which are known to be free from disturbances or irregularities; when such occur, we are then able only to remove or to suffer. Such diseases are but little understood. When the disease is epidemic, some trace its origin to causes which may be termed cosmic. One may be an excess of the decomposing agent, or by conditions of the atmosphere unfavourable to the continuation or tenacity of delicate chemical compounds. Take, as illustration, milk during a thunderstorm; this action is probably caused by a very rapid oxidation, which oxidation begins the phenomena of putrefaction. To bring such an analogy to explain the condition generally of organic matter, is legitimate, and we may either suppose the action to begin in living animals themselves, or on substances external to them. The belief may be said to be established by a long host of great observers, that putrefying matter produces diseases under certain not very well known conditions, and that it reacts unfavourably on the health in every condition, and as a cause of instant death in concentrated forms. In Cairo, where houses are crowded with the living, and where the dead are buried with slight covering, underneath the living, there seems to be a periodic clearing out of the population by plague, reducing the number until there be enough of air to allow of healthy life. In our own prisons at one time the same thing occurred, and in many of the prisons of the world imprisonment is death; such as in Turkey, China, and places not civilised by modern sanitary knowledge. Prisons in Europe, also, might readily be mentioned as most unwholesome; and prisons and workhouses in England itself, where the greatest care must be taken to prevent want of cleanliness, as it produces an immediate result in disease. This is merely on a small scale what takes place on a great scale in nature. It is similar to what we every day see, that man lays hold of some of the facts of nature, and under his hand they act by the same laws as they do in their cosmic manifestations. So in his diseases, man produces them by causing circumstances so to concur that the laws of nature act under his hand as they do when he has not interfered. Sanitary inquirers have ultimately been compelled to attribute many of the greatest effects on health to decomposition of organic matter. Almost all ages have referred to putrefaction or fermentation as an evil. The words have been used synonymously. For various opinions on this subject see DISINFECTION and PUTREFACTION. M. Place, in 1721, says that *in putrefaction a body works another to conformity with itself.* This is believed to be the case in many diseases. One erroneous opinion is very common. Gases which might be prepared in the chemist's laboratory have been blamed as the causes of infectious diseases. Sulphuretted hydrogen and carbonic acid are spoken of as if they were infectious, and productive of fevers. Permanent chemical compounds, gaseous or otherwise, are not capable of acting as infections. The idea of infection given is that of a body in a state of activity. But any gas, the atmospheric mixture excepted, is capable sooner or later of causing death. A true gas diffuses itself in the air, and is rapidly removed from any spot; to render a place long unwholesome the gas must be continuously generated at the spot. The movements of plagues are not similar to anything we know of gases; on the contrary, we know that gases could not move in the manner that cholera and plague do. Sulphuretted hydrogen is not miasma, it is poisonous; it may destroy the constitution and produce diseases which may be deadly enough, but the sources of it are resorted to by invalids; this would never be the case were it a miasm. It has occasionally an internal beneficial action, and although in using it a little be taken into the lungs, this momentary breathing is not found prejudicial; but an amount of cholera infection, such as we could perceive by the nose as readily as sulphuretted hydrogen, would no doubt be a most deadly dose: we probably know of no such amount. The same may be said of carbonic acid and other gases. Some persons are capable of smelling the miasms of certain places—no doubt very fine senses could detect them wherever they existed; but generally bad air may injure very important organs without any effect being perceived by the senses until the evil has become very great. The chemical action is not one that the senses fully observe. Fermentation and putrefaction exhaust their powers after a short time, and cease; so do infections, but not so pure gases, which act only by combining. The fermenting substances lose their power not by combination so much as a change of condition, a transformation of their particles. All these actions, similar to fermentation, are connected with moist bodies: dried bodies cannot ferment, putrefy, or infect. Infection, like fermentation, is most violent at an early stage, gradually spending its strength, and frequently changing a portion of the substance into analogous forms. It has been argued that putrefaction cannot produce disease; but there are no facts in nature better established than the production of disease by the presence of dead animals or vegetables, especially the first. The production of fever by crowding hospitals, barracks, and ships, is as easy as the formation of many other artificial organic actions, although no exact form of fever can be produced at will; cases depending no doubt on time, place, climate, and constitution. The knowledge of these facts concerning zymotic diseases leads to this conclusion: in order to avoid the evil effects of decaying matter, it is necessary to have all our surroundings as clean as possible. Sanitary economy resolves itself at last chiefly into cleanliness. Individuals may learn personal cleanliness, but to render a town or a county clean many difficult arrangements are needed. Impurities arise from the conditions of animal life. Life is generated by the activities of certain substances which compose animals. When the activity is over the substances are dead and unpleasant, and they pass into their former condition through a number of stages. In some of these stages the substances are gaseous, some liquid, some solid; we may add, some in the state of vapour. Some of these substances are exhalations, some excretions. Exhalations come from the surface of the whole body, but from the lungs principally. The lungs give out air with about 4, 6, and even 8 per cent. of carbonic acid in it, and the amount respired is about 380 cubic feet in 24 hours, about 31 cubic inches per respiration, and 15 respirations per minute. The amount of air proposed as the supply for an individual varies greatly. Dr. Reid gave 30 cubic feet per minute = 1800 feet per hour, and even 3600. Liebig supposes 216 feet per hour. Dr. Reid gave more than was considered agreeable. Brennan supposes about 600, and calculates the following for every room per minute and per individual, the air being at 64°, and dew point at 50°.

For supply to the lungs - - - - -	0·83 feet.
To carry off insensible perspiration - - -	10·2 „
For each common-sized candle - - - -	0·25 „

If heated air is used for warming—

For each square foot of glass in the window -	1·0 „
Each window to make up for leakage - - - -	8·5 „
Each door for the same - - - - - - -	5·2 „
Each 200 square feet of wall and ceiling - -	1 „

Allowing this to be excessive, the advantage of pure air is still to be urged, and it is desired most by the healthiest specimens of men.

In speaking of the impure gases of the air, carbonic acid is generally referred to. This carbonic acid has been considered to be the great cause of disease in crowded localities, but the conclusion is contrary to our knowledge of the effects of carbonic acid when pure. There can be little doubt that there is a considerable amount of organic matter in the air of crowded places, and to that organic matter must be attributed most of the evil. It may be true that 1 per cent. of carbonic acid may be observed by the senses, but this is generally tried with carbonic acid given out from the lungs. In the case of a prison in Germany, 2 per cent. of carbonic acid was found in the air. Skin diseases appeared rapidly, and deaths were excessive. But we do not know the action of the pure gas; there must have been a large amount of corrupt matter in air which contained 2 per cent. of carbonic acid escaped from persons. It shows also great general filth. Amounts of organic matter, which are wonderfully less than even an hundredth of a per cent., are known to make the air unhealthy. In Manchester it seems to be the sulphurous acid which is chiefly felt, and that when it is less than one in a million, although it rises up in some places close to chimneys to 1, and even 4, in 100,000.

It is not intended here to give statistics of disease, but it will be right to refer to the enormous amount of disease amongst miners in Cornwall. The depths being great, above 1800 feet in some, and the temperature rising to about 100°, the difficulty of working is extremely great. Candles are burnt, and the air has become so deteriorated that it contained less than 18 per cent. of oxygen. The amount of carbonic acid had not risen above 0·085 per cent., which is not very high. Mr. R. Q. Couch, Sir J. Forbes, and Mr. Mackworth, have successively reported on this subject and given some interesting details. Mr. Roberton, of Manchester, remarks on the great cleanliness of the women; but they do not enter the mines, and their lives are longer. Consumption destroys the men rapidly in many of the deep mines.*

Exhalations from the skin are abundant, both acid and oleaginous.

Dr. Vogel found organic matter in the air of his class-rooms after a lecture. Dr. Angus Smith has shown that the exhalations may be traced on the walls of crowded rooms, which become coated with organic matter; and he adds that the furniture becomes coated with a similar substance, which must be continually removed. Thus furniture and walls which are never touched in time become impure, and give out noxious exhalations when these substances begin to decompose. Again, these substances are caught in our clothes and are retained there in a decided manner, on account of a peculiar faculty of retention in the fibre. This necessitates constant washing. Long custom has shown, that when retained by the cloth, a certain amount of it becomes innocent; that is, different fibres have the power of retaining matter so firmly that it is imperceptible and incapable of acting on the air. Wool has this faculty to a great extent; linen and cotton to a less extent. For this reason wool can be worn longer next the skin, remaining in reality clean. Clothes that are to be kept in good condition, if made of wool, as men's coats, cannot be washed: for this reason the custom has gradually been formed of wearing under clothing, which absorbs condensible substances especially, and is then washed, keeping the exterior clothing for a long time clean. As porous substances have an oxidising power, it is probable, that if not too much organic matter is supplied, the exterior clothing, well aired, may be kept absolutely clean, not merely by our ordinary practice of brushing and dusting, but also by oxidation, in the same way as Dr. Stenhouse has shown oxidation to take place in pores of charcoal. The instant removal of the breath and other exhalations is of great importance. This properly comes under the head of warming and ventilating. Walter Brennan, C.E., in his "History of Warming and Ventilating," gives a remarkable amount of information. There have been many mistakes as to the effect of overcrowding; its evils have actually been denied. The facts are very decided. Isolated houses may be crowded so much as to produce diseases, or they may be so badly ventilated without crowding as to have the same result. In this way persons in the country may have all the disadvantages of a crowded town. Again, a town-house well ventilated may have many of the advantages of the country, because, although the air is not of the purest, it may never be allowed to sink below the average purity of the external air. Indeed, freedom from disease is obtained in towns better in all cases than where there is a malarious atmosphere outside the town: this, of course, is well known; and at the same time diseases from putrefaction, caused by want of space and cleanliness, are cured by leaving a town. Persons slightly exposed to the odour of water-closets in towns are frequently subjected to disease, the unoxidised air poisoning them, whilst persons working in the open air escape, although labouring amongst the excreta themselves. Again, persons living in the house are exposed to the excreta a day or two old, whilst, in the case of nightmen, it has frequently passed its worst stage when they approach it. The stage giving off sulphuretted hydrogen is by no means the worst, perhaps one of the most innocent of the unpleasant stages, unless this gas be very strong, when it is fatal. But even in the minutest quantity this gas is hurtful to persons continuously exposed.

* "*Miner's consumption*," as the disease which destroys the miner is named, prevails also in the lead mines of the northern counties, which are usually shallow.—(*Ed.*)

The mode of removing excreta is an important point. Most inquirers have decided against leaving them in a town, and against allowing them near a house. These conclusions are especially valuable for town houses. We have in some towns whole streets of middens behind the houses, and the air behind is always inferior to the front air. The process of carting refuse is also a great evil in a town. No plan removes filth so rapidly as that with water. Many people object to it, because we have not yet learnt to make good sewers. Sewers should be tight. The Board of Health introduced small and rapid streams in the sewers, objecting to the canal-like sewers, which are as bad as cesspools, on account of the enormous amount of deposit in them, and are reservoirs of foul air from the amount of putrefaction going on within them. Many persons, not seeing this evil, have desired again to return to the no-plan of middens, not seeing what a deplorable result has been attained in Paris, where although using air-tight vessels to remove the refuse, they render most of the houses redolent of night-soil. The towns treated on the rapid removal system are models of cleanliness, and we do not doubt the speedy increase of the plan, especially as carried out by Robert Rawlinson, C.E. It must be confessed, however, that the great objection to the plan is one which is not to be despised. There is too much water used; if the water flows into the streams they are spoiled, and it is scarcely possible to put it on land. This difficulty must be met, or the plan so admirable for towns will be found destructive to countries. There is one way of meeting it, that is, by making the liquid denser, and so having it so strong as to be a valuable manure. By a double system of drainage this might be effected, the rain water going in a separate sewer. *F. O. Glassford* proposes a water-closet which shall hold the excreta till they are mixed up to a thickish liquid with water; he then removes it by pipes to certain reservoirs, and makes solid manure from it by sulphuric acid and evaporation, a plan which he has found to answer. Dr. Joule proposes large iron tanks for each block of houses, to be emptied daily, and disinfected on being emptied. All such plans must be inferior to the cleanliness caused by abundant water. We must learn to remove our filth from our towns, or they will be as unwholesome as they once were. Nothing but abundant water can make the largest city in the world (London) the healthiest of large cities.

The assertion of the Board of Health is that combined works, comprising a water-pipe for the service of each house, a sink, a drain, and a waste-pipe, and a soil pan or water-closet apparatus, may be laid down and maintained in action at a cost not exceeding on the average three halfpence per week, or less than half the average expense of cleansing the cesspool for any single tenement. This seems borne out by the example of several towns under the care of engineers penetrated with the spirit which dictated the changes. To the above amount has been added water supply, which has increased the sum to threepence per week.

Sewers must certainly not leak, or they must be disinfected. Dr. Angus Smith proposed long ago that they should be disinfected nearly from their sources. In other words, disinfectants should flow through all the great sewers, and so bring them to the rivers in a state where putrefaction is impossible. The advantage of this would be great. When Mr. McDougall was showing his plan of disinfecting sewers to the Board of Works, the smell of the substance he used when he tried it in excess was perceived in the houses along the line of the sewer, showing clearly that the present sewers allow their filthy smells to go into the air of houses. He completely destroyed the sewer smell. To prevent bad air in sewers, some persons, and amongst others some in the Board of Health, have proposed ventilation, and have thus polluted towns with the air which, after all, may be better where it was. To obviate this, they sometimes filter the air through charcoal before allowing it to escape. No plan will succeed but that which, by preventing putrefaction, prevents entirely the formation of foul air. At present all the lines of sewers are unclean; they may all be cleaned by antiputrescent substances. If every family used them, even the smallest drains would be disinfected with universal benefit. Of course the Thames would cease to putrefy if the larger sewers were all treated in this way.

When the excretions are allowed to accumulate in a town behind the houses, as in Leeds and many other large manufacturing towns, they must of course be periodically removed, as the amount of impure vapour is very much in proportion to the surface exposed. There is little improvement caused by slightly diminishing the solid contents. When removed, it must be taken either to deposits in the town, as at Manchester, or deposits out of the town, as at Paris. It cannot, except in small towns, be removed directly to the land, as the demand is not regular. In both cases the removal is a great grievance, and the places of deposit are unseemly, especially near Paris, at Bondy, where a great district becomes uninhabitable. If removed by water, either the streams must be polluted, or sewers must be carried along the streams very far. If the sewer matter is first disinfected in the sewers, it will flow without disturbing any one; and if not so much diluted with surface matter as at present, it might be put at once on the land, without any one knowing by the smell that it differed from pure water.

Since Edwin Chadwick, C.B., and Dr. Southwood Smith, whether under the name of the Board of Health, or Sanitary Commissioners, or other name, stimulated the country to sanitary purposes, the supply of water and every other progress relating to health has undergone a great change. Professor Clark first showed the advantages of soft water; and, wherever it can be obtained, it is now used in towns. Every town which can obtain it has now a supply of water; and the supply in many is constant. The loss of labour to a family where water is obliged to be carried from a well is sometimes equal to that of one person for at least one third of a day. And even with this loss there is an insufficient supply, which adds to the inconveniences of a household, and the loss of comfort and of health. As towns enlarge, and as houses become higher, the necessity for a supply being introduced into houses increases. In Glasgow there is a supply from Loch Katrine, 34 miles distant. The supply in Scotch houses must be taken to the highest storey of the houses, on account of the system of living in flats, and because in the large towns almost every family has a water-closet and a bath.

The cleaning of the surface of streets is another important point in sanitary economy. Abundance of water for this purpose would be a great advantage; but the plan is not introduced here. The Whitworth sweeping machine was a good cleanser, but it was very heavy, and the cartage became expensive. Hand sweeping is still resorted to. If disinfecting agents were put into the water-carts which watered the streets, the putrefaction going on there in great abundance would be arrested, and the disinfected matter would flow into the sewers, which would then be free from impure air, and would run into the river in a state that would not corrupt. This was also proposed, in addition to the method alluded to of disinfecting sewers, and by the same persons. After the towns and their immediate neighbourhoods have been purified, it is needful to purify the land. The great sources of malaria are not known; but it is abundantly known that badly-drained land, especially at a high temperature, is productive of malaria; and that even at a moderate temperature malaria causes intermittent attacks. Drainage has greatly removed ague from this country; it has cleared the land; and the atmosphere has become brighter, because the dried land has not produced so many fogs as that which was cold and wet. The clearing of swamps was a labour of Hercules, no less valuable now. The agricultural or money value of land has, at the same time, greatly increased.

Towns.—It has been shown that a death-rate of 22 per thousand yearly prevails in England, but that in large manufacturing towns it rises to 34, and in certain parts of them even to 45, whilst in small and healthy places it is as low as 17, and in some cases even less so. The loss of life is great, and the loss of property also. A great object of sanitary reformers has been to show that to improve health has been to improve property. There can be no doubt of it. Disease causes much loss of time and labour, and diminishes the power of a country in which it exists. We may very fairly calculate from the amount of deaths the amount of disease. To improve our health is to improve our happiness and our wealth, as well as our capacities for both. Although in some country places malaria may cause illness, and ignorance may in various ways induce most unwholesome habits, there is less fear of disease on an average far from a town, because of the tendency of persons to live out of doors, breathing pure air, for in most places it is pure. In towns we are not only apt to be more shut up, and to have less exercise, but we are exposed to all the impurities which arise from the neighbourhood of multitudes, as well as from the vapours and gases from manufactures. Many chemists have found it difficult to tell the difference between town and country air, and have denied any difference; but it is now proved abundantly. The very rain of towns where much coal is burnt is so acid, that a drop falling on litmus renders it red. Blood shaken with the air of towns takes a different shade from that shaken with pure air. The air of Manchester contains about 0·0000934 of sulphurous acid, partly sulphuric, into which the first changes. Dr. Angus Smith has shown a method of measuring the amount of impurity in the air by means of a very dilute solution of permanganate of potash. His results are obtained by filling a bottle with the air of the place, merely by pumping the air out and allowing the air around to enter. A little permanganate is poured into the bottle, and it is decolorised; more is added until the colour remains. By this means comparative amounts of oxidisable matter are readily measured. A pigstye required 109 measures; air from the centre of Manchester air, on an average 58; air over the Thames, when the putrid stage had just passed, 43; London, 29; after a storm at Camden Town, 12; fields near Manchester, 13·7; German Ocean, 3·3; Hospice of St. Bernard, in a fog, 2·8; Lake of Lucerne, calm, 1·4. When sulphurous acid and sulphuretted hydrogen are present, the action is instantaneous: when organic matters only are present, the result is obtained more slowly. The difference between town and country air is remarkable. The author hopes to make the experiment suitable for daily use in hospitals. The bottle used contains about 100 cubic; the solution of permanganate is graduated by a standard solution of oxalic acid, of which 1000 grains contain 1 of anhydrous oxalic acid. 5 grains of this solution decompose 600 grains of the solution of permanganate.

To prevent impurities in the air of towns is extremely difficult. Manufactures must not be crippled; certain noxious operations are not allowed, and complaints well substantiated against any offensive works compel their removal. The method of absorbing noxious gases of some kinds is now becoming usual. The coke towers for absorbing muriatic acid began a great change in this respect. They have been used for sulphuric acid itself, nitrous fumes, sulphurous acid, sulphuretted hydrogen, &c. In manufacturing towns there is little sulphuretted hydrogen — it is decomposed rapidly by the sulphurous acid. A mode of absorbing this latter acid from coal smoke would be a great blessing to all. But this would not remove all the evil; coals send out black soot in such abundance that the whole of a town is darkened, everything clean is made impure, and the people find that cleaning is a hopeless task. This might readily be burnt, but even then we have other difficulties. Ashes rise up in great amount, and fall down again in a perpetual shower of dust. It is these solid matters as well as the gases which render our towns unwholesome. If the smoke could be washed it would remove all these evils, but the loss of a draught to the fire is then a consequence not yet practically overcome. When coals are burnt with abundance of lime, no sulphur is given off, but the use of this cannot become general. We are very much in want of a more economical and wholesome method of obtaining from coals the power which is in them.

Mr. Spence of Manchester, proposes to connect all the furnaces of the city with the sewers, and thereby to burn the gases and to ventilate the sewers at the same time. He believes that one chimney will ventilate readily 500 houses, including the house drains and sewers also.

The following advantages to be derived from the drainage of suburban land have been mentioned by the Board of Health: — 1. The removal of that excess of moisture which prevents the permeation of the soil by air, and obstructs the free assimilation of nourishing matter by the plants. 2. Facilitating the absorption of manure by the soil, and so diminishing its loss by surface evaporation, and being washed away by heavy rains. 3. Preventing the lowering of the temperature and the chilling of the vegetation, which diminishes the effect of solar warmth, not on the surface only, but at the depth occupied by the roots of plants. 4. Removing obstructions to the free working of the land, arising from the surface being at certain times, from excess of moisture, too soft to be worked upon, and liable to be poched by cattle. 5. Preventing injuries to cattle or stock, corresponding to the effects produced on human beings by marsh miasm, chills and colds, inducing a general low state of health, and in extreme cases the rot or typhus. 6. Diminishing damp at the foundations of houses, cattle sheds, and farm steadings, which cause their decay and dilapidation, as well as discomfort and disease to inmates and cattle.

The Board of Health, in its excessive desire to remove all refuse by water, has often exaggerated the evils of every other aid to cleanliness. Water is unquestionably the best, but it cannot always be obtained. In some climates it is not to be found in abundance, and in some weather it is only to be had by the use of heat. When the cold is great there is no fear of putrefaction or putrid gases; in warm places, or even in temperate, the use of disinfectants before removing the putrid matter is much to be desired. The Board of Health has not feared to send putrid matter into a river, believing it better there than in the town; it desires the water to be put instantly on the land, and to be disinfected by the land. It is well known that the process of doing this is often offensive. It is also known that large quantities of this matter cannot be disposed of at all times. It has been said that if the liquid were diminished by the rain-fall, it might be manageable. There is another method of diminishing its amount. At Carlisle it was found that the water was almost pure at certain hours of the day, and at all hours of the night. By allowing the more impure only to run into the sewers, the quantity not only becomes manageable, but the quality becomes more valuable. This is an important point, but one which will probably be less apparent in such a place as London, where the changes occurring from hour to hour cannot be so great as in smaller places. In Carlisle the sewage is deodorised and used on the meadows, and a great problem seems there and elsewhere to have begun its solution.

Sanitary economy has proceeded chiefly under the impression that the pollution of the air is the evil most to be dreaded. That this idea is correct there are very many proofs; but that there are numerous other evils affecting our large towns, it is unwise to deny. Polluted air causes damp and close cellars, and unventilated garrets and other rooms, to be unwholesome, as well as all rooms without proper openings, without chimneys, and without opening sashes to the windows. In a word, polluted air rises from close places and dirty places; want of light, too, is an evil under which all living creatures suffer. Great and crowded towns are subject most to all these evils, but in them also the habits of the people come into consideration. In many of the manufacturing towns the people obtain much larger wages than in the country places, but their houses are badly furnished, and their clothes, for every-day at least, are extremely filthy, whilst their love of pleasure is excessive. It is commonly supposed that the love of pleasure exists among the rich, but it is unquestionably one of the greatest evils *oppressing* the poor in all large towns, because their cultivation of mind has not kept pace with their knowledge of the external appliances of civilisation.

A deficient intellectual and moral condition are the great causes both of poverty and bad health, for both go together in almost exact proportions. It must never be expected that pure air alone can make men healthy. The mind, as well as the body, must be freed from irregularities. Abundant wages, which are equal to facilities of health, have rendered our working classes inferior in some cases, both in body and in mind, because they have not had education to resist indulgence. These classes will often contrast badly with a poor but cleanly rural population, calm in mind, without a desire for excitement. The subject is here only slightly touched, it needs a volume: sanitary economy, or the method by which man best adapts his place of abode to the conditions of external nature, must ever be a study of the most absorbing interest. — R. A. S.

SAPAN WOOD, or EAST INDIAN DYE WOOD, or BUCKUM WOOD, is a species of the *Cæsalpinia* genus, to which Brazil wood belongs. It is so called by the French, because it comes to them from Japan, which they corruptly pronounce Sapan. It is imported in pieces like the Brazil wood, to which it is far inferior for dyeing. The decoction under the name of sapan liquor is used in calico printing for red colours. In general, sapan wood is too unsound to be employed for turning.

SAP GREEN. The juice of the berries of the *Rhamnus catharticus*, or common buckthorn.

SAPPHIRE. The *Sapphire*, *Ruby*, *Oriental Amethyst*, *Oriental Emerald*, and *Oriental Topaz*, are gems next in value and hardness to diamond; and they all consist of nearly pure alumina or clay, with a minute portion of iron as the colouring matter. The following analyses show the affinity in composition of the most precious bodies with others in little relative estimation.

	Sapphire.	Corundum Stone.	Emery.
Alumina or clay -	98·5	89·50	86·0
Silica - - -	0·0	5·50	3·0
Oxide of iron - -	1·0	1·25	4·0
Lime - - -	0·5	0·00	0·0
	100·0	96·25	93·0

Salamstone is a variety which consists of small transparent crystals, generally six-sided prisms, of pale reddish and bluish colours. The corundum of Battagammana is frequently found in large six-sided prisms: it is commonly of a brown colour, whence it is called by the natives *curundu gallé*, cinnamon stone. The hair-brown and reddish-brown crystals are called adamantine spar. Sapphire and salamstone are chiefly met with in secondary repositories, as in the sand of rivers, &c., accompanied by crystals and grains of octahedral iron-ore and of several species of gems. Corundum is found in imbedded crystals in a rock, consisting of indianite. Adamantine spar occurs in a sort of granite.

The finest varieties of sapphire come from Pegu, where they occur in the Capelan mountains near Syrian. Some have been found also at Hohenstein in Saxony, Bilin in Bohemia, Puy in France, and in several other countries. The red variety, the ruby, is most highly valued. Its colour is between a bright scarlet and crimson. A perfect ruby above 3½ carats is more valuable than a diamond of the same weight. If it weigh 1 carat, it is worth 10 guineas; 2 carats, 40 guineas; 3 carats, 150 guineas; 6 carats, above 1000 guineas. A deep coloured ruby, exceeding 20 carats in weight, is generally called a carbuncle; of which 108 were said to be in the throne of the Great Mogul, weighing from 100 to 200 carats each; but this statement is probably incorrect. The largest oriental ruby known to be in the world, was brought from

China to Prince Gargarin, governor of Siberia. It came afterwards into the possession of Prince Menzikoff, and constitutes now a jewel in the imperial crown of Russia.

A good blue sapphire of 10 carats is valued at 50 guineas. If it weighs 20 carats, its value is 200 guineas; but under 10 carats, the price may be estimated by multiplying the square of its weight in carats into half a guinea; thus, one of four carats would be worth $4^2 \times \frac{1}{2}G. = 8$ guineas. It has been said that the blue sapphire issuperior in hardness to the red, but this is probably a mistake arising from confounding the corundum ruby with the spinelle ruby. A sapphire of a barbel blue colour, weighing 6 carats, was disposed of in Paris by public sale, for 70*l.* sterling; and another of an indigo blue, weighing 6 carats and 3 grains, brought 60*l.*; both of which sums much exceed what the preceding rule assigns, from which we may perceive how far fancy may go in such matters. The sapphire of Brazil is merely a blue tourmaline, as its specific gravity and inferior hardness show. White sapphires are sometimes so pure, that when properly cut and polished they have been passed for diamonds.

The yellow and green sapphires are much prized under the names of oriental topaz and emerald. The specimens which exhibit all these colours associated in one stone are highly valued, as they prove the mineralogical identity of these varieties.

Besides these shades of colour, sapphires often emit a beautiful play of colours, or *chatoiement*, when held in different positions relative to the eye or incident light; and some likewise present star-like radiations, whence they are called star-stones or *asterias;* sending forth 6 or even 12 rays, that change their place with the position of the stone. This property, so remarkable in certain blue sapphires, is not however peculiar to these gems. It seems to belong to transparent minerals which have a rhomboid for their nucleus, and arises from the combination of certain circumstances in their cutting and structure. Lapidaries often expose the light-blue variety of sapphire to the action of fire, in order to render it white and more brilliant; but with regard to those found at Expailly in France, fire deepens their colour.

SARD. A variety of chalcedony of a dark reddish-brown colour, almost approaching to black by reflected light, and very deep red, inclining to blood-red, by transmitted light. It is found under the same conditions as cornelian, but is rarer and more highly esteemed, and therefore fetches a higher price. The name is derived either from Sarx (*Greek*, flesh), in allusion to its colour, or from Sardis in Lydia, whence it is said to have been first brought. It should be remarked, however, that the sard presents, in its interior and in the middle of its ground, concentric zones, or small nebulosities, which are not to be seen in the red cornelian, properly so called. The ancients certainly knew our sard, since they have left us a great many of them engraved, but they seem to have associated under the title *sarda* both the sardoine of the French, and our cornelians and chalcedonies. Pliny says that the sarda came from the neighbourhood of a city of that name in Lydia, and from the environs of Babylon. Among the engraved sards which exist in the collection of antiques in the Bibliothèque Royale of Paris, there is an Apollo remarkable for its fine colour and great size. When the stone forms a part of the agate-onyx, it is called sardonyx. For further details upon Gems, and the art of cutting and engraving them, see LAPIDARY.—H. W. B.

SARDONYX. A variety of onyx, composed of alternate layers of sard and white chalcedony.—H. W. B.

SATIN (Eng., Fr. and Germ.) is the name of a silk stuff, first imported from China, which is distinguishable by its very smooth, polished, and glossy surface. It is woven upon a loom with at least five-leaved healds or heddles, and as many corresponding treddles. These are so mounted as to rise and fall four at a time, raising and depressing alternately four yarns of the warp, across the whole of which the weft is thrown by the shuttle, so as to produce a uniform smooth texture, instead of the chequered work resulting from intermediate decussations, as in common webs. Satins are woven with the glossy or right side undermost, because the four-fifths of the warp, which are always left there during the action of the healds, serve to support the shuttle in its race. Were they woven in the reverse way, the scanty fifth part of the warp threads could either not support, or would be too much worn by the shuttle. See TEXTILE FABRICS.

SATURATION is the term employed to express the condition of a body which has taken its full dose or chemical proportion of any other substance with which it can combine: as water with a salt, or an acid with an alkali. See *Ure's Dictionary of Chemistry* for a development of the principles and peculiarities attending this process.

SATURN, EXTRACT OF. The old name of the acetate of lead.

SAWS. Saws are formed from plates of sheet steel, and are toothed, not by hand,