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THE

CHEMISTRY OF COMMON LIFE.

BY

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CONTENTS OF VOL. II.

CONTENTS.

CHAPTER XV.

THE NARCOTICS WE INDULGE IN.

TOBACCO.

Man's wants progressive.—How he ministers to them.—Narcotics now in use in different parts of the world.—Tobacco brought to Europe from America.—Its rapid spread over the globe.—Its extended use.—Opposition encourages it.—Is it indigenous in China as well as America?—Present consumption in the United Kingdom.—It is rapidly increasing.—Circumstances which affect the quality of tobacco—Where the best qualities grow.—Forms in which tobacco is used.—Manufacture of snuff.—Effects produced by tobacco.—It soothes and excites.—Influence of climate, constitution, and temperament, in modifying its effects.—Interesting physiological facts.—Does it necessarily provoke to dissipation?—Is the tobacco reverie a mere absence of thought?—Chemical ingredients of the tobacco.—The volatile oil.—The volatile alkali.—The empyreumatic oil.—Proportion of these poisonous substances is variable.—Chemical differences between smoking, chewing, and snuffing.—Cause of diversities in the quality of tobacco.—Adulterations of tobacco.—The ash of the tobacco leaf.—The growing of tobacco an exhausting culture.

Akin to the intoxicating liquors we consume are the narcotic substances we indulge in; and if the history of the former, in their relations to the social state, be full of a melancholy interest, that of the latter is still more striking and extraordinary. I may say, indeed, that to the economical statist, not less than to the physiologist and psychologist, the connection of man with the narcotics in common use,

in different countries, forms one of the most wonderful chapters in his entire history.

In ministering fully to his natural wants and cravings, man passes through three successive stages.

First, the necessities of his material nature are provided for. Beef and bread represent the means by which, in every country, this end is attained. And among the numerous forms of animal and vegetable food which different nations make use of in the place of these two staples of English life, a wonderful similarity in chemical composition prevails. Exactly the same gluten and starch and fat are supplied to the body in every country, and nearly in the same proportions—so that we are constrained to admire what may be called the universal instinct by which, under so many varied conditions of climate and of natural vegetation, the experience of man has led him everywhere to adjust in the nicest manner the chemical constitution of the staple forms of his diet to the chemical wants of his living body.*

Next, he seeks to assuage the cares of his mind and to banish uneasy reflections. Fermented liquors are the agents by which this is effected. And here also it is interesting to remark, not only that this lightening of care is widely and extensively attained, but that the chemical substance, by the use of which it is brought about, is everywhere one and the same. Savage and civilized tribes, near and remote—the houseless barbarian wanderer, the settled peasant, and the skilled citizen—all have found out, by some common and instinctive process, the art of preparing fermented drinks, and of procuring for themselves the enjoyments and miseries of intoxication. And thus, whatever material is employed for the purpose, whether the toddy of the palm tree, the sap of the aloe, the juice of the sugar cane, the

* See The Bread we Eat and the Beef we Cook.

syrup of honey, the must of the grape, the expressed liquor of the apple and pear, the wort of malted grain, or the milk of the Tartar mare—in every instance the substance called alcohol is produced by the fermentation, and forms the intoxicating ingredient of the liquor.

And lastly, he desires to multiply his enjoyments, intellectual and animal, and for the time to exalt them. This he attains by the aid of narcotics. And of these narcotics, again, it is remarkable that almost every country or tribe has its own, either aboriginal or imported; so that the universal instinct of the race has led, somehow or other, to the universal supply of this want or craving also.

The aborigines of Central America rolled up the tobacco leaf, and dreamed away their lives in smoky reveries, ages before Columbus was born, or the colonists of Sir Walter Raleigh brought it within the precincts of the Elizabethan court. The coca leaf, now the comfort and strength of the Peruvian muletero, was chewed as *he* does it, in far remote times, and among the same mountains, by the Indian natives whose blood he inherits. The use of opium, of hemp, and of the betel-nut among Eastern Asiatics, mounts up to the times of most fabulous antiquity. The same probably is true of the pepper plants among the South Sea Islands and the Indian Archipelago, and of the thorn-apples used among the natives of the Andes, and on the slopes of the Himalayas; while in Northern Europe the ledum and the hop, and in Siberia the narcotic fungus, have been in use from time immemorial.

As from different plants, in different parts of the world, the favourite intoxicating liquor was obtained, so from different plants the favourite narcotic was extracted by different races of men. But this important difference prevails between the two classes of indulgences, that while in all the fermented liquors, as I have said, the same alcohol or in-

toxicating spirit exists, each narcotic in use contains its own peculiar principle. From whatever source obtained, the fermented liquor produces nearly the same effect upon the human system. But each narcotic indulgence produces its own peculiar and special effect. Tobacco and opium, and hemp and coca, and the hop and the toad-stool, while they all exercise a narcotic influence upon the human frame, do so in a form and with modifications which in each case are peculiar, in many respects full of interest, and always worthy of deep study and consideration. These narcotic substances, therefore, occupy an important place in the chemistry and chemico-physiology of common life.

I. Tobacco.—Of all the narcotics I have mentioned, tobacco (fig. 56) is in use over the largest area, and among the greatest number of people. Opium is probably next to it in these respects, and the hemp plant occupies the third place.

Tobacco is believed to be a native of tropical America; at all events, it was cultivated and used by the native inhabitants of various parts of that continent long before its discovery by Europeans. In 1492, Columbus found the chiefs of Cuba smoking cigars, and Cortes met with it afterwards, when he penetrated to Mexico. From America it was introduced into Spain by the Spaniards, it is not certain in what year. In 1560 it was brought to France by Nicot, and in 1586 to England by Sir Francis Drake, and the colonists of Sir Walter Raleigh. Into Turkey and Arabia, according to Mr. Lane, it was introduced about the beginning of the seventeenth century, and in 1601 it is known to have been carried to Java. Since that time both the cultivation and the use of the plant have spread over a large portion of the habitable globe.

Thus the different parts of America in which it is now

grown include Canada, New Brunswick, the United States, Mexico, the western coast as far as 40° south latitude, Brazil, Cuba, Trinidad, and the other West India Islands. In Africa it is cultivated on the Red Sea and the Mediterranean, in Egypt, Algeria, the Canaries, along the western coast, at the Cape of Good Hope, and at numerous places in the interior of the continent. In Europe, it has been raised with success in almost every country, and it forms at present an important agricultural product in Hungary, Germany, Flanders, and France. In Asia, it has spread over Turkey, Persia, India, Thibet, China, Japan, the Philippine Islands, Java, Ceylon, Australia, and New Zealand. Among narcotic plants, indeed, it occupies a similar place to that of the potato among food plants. It is the most extensively cultivated, the most hardy, and the most tolerant of changes in temperature, altitude, and general climate. From the equator to the fiftieth degree of latitude it may be raised without difficulty, though it grows best within thirty-five degrees of latitude on either side of the equator. The finest qualities are raised between the fifteenth degree of north latitude, that of the Philippines, and the thirty-fifth degree, that of Latakia in Syria.

Fig. 56.

Nicotiana tabacum—The Virginia Tobacco.
Scale, 1 inch to a foot and a half.

1°. Extensive Use of Tobacco.—And the use of the

plant has become not less universal than its cultivation. Next to salt, it is supposed by some to be the article most extensively consumed by man. Tea alone can compete with it; for although it may not be in use over so large an area, tea is probably consumed by as great a number of the human race.* In America, tobacco is met with everywhere, and the consumption is enormous. To its use in some parts of the United States, at the present moment, King James's description, in the opinion of many, applies more justly than to the practice in any other part of the world—"A custom loathsome to the eye, hateful to the nose, harmfull to the brain, dangerous to the lungs, and in the black stinking fume thereof neerest resembling the horrible Stygian smoake of the pit that is bottomless."

In Europe, from the plains of sunny Castile to the frozen Archangel, and from the Ural to Iceland, the pipe, the cigar, and the snuff-box, are a common solace, among all ranks and conditions of men. In vain, when it first came among us, King James opposed it by his *Counterblast to Tobacco;* in vain Pope Urban the Eighth thundered out his bull against it; in vain was the use of it prohibited in Russia, and the knout threatened for the first offence, and death for the second. Opposition and persecution only excited more general attention to the plant, awakened curiosity regarding it, and tempted people to try its effects.

So, in the East, the priests and sultans of Turkey and Persia declared smoking a sin against their holy religion; yet the Turks and Persians have become the greatest smokers in the world. In Turkey, the pipe is perpetually in the mouth. In India, all classes and both sexes smoke. The Siamese chew moderately, but smoke perpetually. The Burmese of all ranks, of both sexes and of all ages,

* See what is said in the succeeding chapter as to the consumption of the hop in England.

down even to infants of three years old, smoke cigars—(CRAWFORD). In China the practice is so universal that every female, from the age of eight or nine, wears, as an appendage to her dress, a small silken pocket to hold tobacco and a pipe.

Indeed, from the extensive prevalence of the practice in Asia, and especially in China, Pallas argued long ago that the use of tobacco for smoking in those countries must be more ancient than the discovery of America. "Amongst the Chinese," he says, "and amongst the Mongol tribes, who had the most intercourse with them, the custom of smoking is so general, so frequent, and has become so indispensable a luxury; the tobacco-purse affixed to their belt so necessary an article of dress; the form of the pipes, from which the Dutch seem to have taken the model of theirs, so original; and lastly, the preparation of the yellow leaves, which are merely rubbed to pieces, and then put into the pipe, so peculiar, that they could not possibly derive all this from America by way of Europe, especially as India, where the practice of smoking is not so general, intervenes between Persia and China." *

This opinion of Pallas has since been supported by high botanical authorities. Thus Meyen says: "It has long been the opinion that the use of tobacco, as well as its culture, was peculiar to the people of America; but this is now proved to be incorrect, by our present more exact acquaintance with China and India. The consumption of tobacco in the Chinese empire is of immense extent, and the practice seems to be of great antiquity, for on very old sculptures I have observed the very same tobacco-pipes which are still used. Besides, we now know the plant which furnishes the Chinese tobacco; it is even said to grow wild in the East Indies. It is certain that this to-

* Quoted in M'CULLOCH'S *Commercial Dictionary*, ed. 1847, p. 1314.

bacco plant of Eastern Asia is quite different from the American species." *

According to the recent travellers, Messrs. Huc and Gabet, the yellow tobacco of eastern Thibet and western China is the leaf of the *Nicotiana rustica*. In flavour it resembles the finest Syrian tobacco, which is also the leaf of the *N. rustica*. The tobacco of central and southern India is the *Nicotiana tabacum*, or Virginian tobacco; that of northern India, the *N. rustica*—(HOOKER).

The common green tobacco (fig. 57) is a smaller plant than the Virginian, being only 3 to 5 feet in height, and has shorter and broader leaves, and smaller flowers, with rounded instead of pointed segments. It is the species generally cultivated in Russia, Sweden, and North Germany, and two varieties of it are grown in some parts of Ireland, under the names of Oronooko and Negrohead. It is said, I do not know upon what authority, to have been imported to Britain from America in 1570. The variety cultivated in China is still smaller than the one represented in the above figure.

Fig. 57.

Nicotiana rustica—
Common green Tobacco.
Scale, 1 inch to the foot.

If this be really the species cultivated in western China, the argument of Meyen loses much of its weight, and the opinion that eastern Asia did not derive the use of tobacco from America must rest chiefly on the general prevalence and antiquity of the custom in China. Other late writers, indeed, dissent from this opinion, and consider that there can hardly be a doubt but

* *Botanical Geography* (Ray Society), 1846, p. 361.

that tobacco was introduced into the different countries of the East from Europe, and by Europeans—(CRAWFORD). Other considerations, however, which it would be out of place here to discuss, incline me to regard its introduction in this way as less certain than it appears to Mr. Crawford. The truth may possibly be, that species of the tobacco plant are native to Europe and Asia as well as to America, and that only the *custom* of using them as narcotics was introduced into Western Europe from the New World.

But whichever of these opinions we adopt in regard to the East, still, one of the most remarkable circumstances connected with the history of tobacco is the rapidity with which its growth has spread, and its consumption increased, in those countries to which we are certain that the use of it came from America. In 1662, the quantity raised in Virginia, then the chief producer of tobacco on the American shores of the Atlantic, was only 60,000 lb., and the quantity exported from that colony in 1689 only 120,000 lb. During the 160 years which have since elapsed, the produce of this coast has risen to nearly twice as many millions of pounds!

The enormous extent to which its use has increased in our own country, may be judged of from the fact, that while in the above-mentioned year (1689) the total importation was only 120,000 lb. of Virginian tobacco, part of which was re-exported, the consumption in the United Kingdom is at present about 30,000,000 lb.! Thus the quantity entered for home consumption in—

1851	was	28,062,841 lb.
1852	"	28,558,733 "
1853	"	29,737,561 "

And to this must be added the large quantity of contraband tobacco, which the heavy duty of 3s. a lb. tempts the smuggler to introduce.

That the consumption among us is still rapidly on the increase, appears from the above numbers; but it is more clearly shown by the following table, which exhibits the quantities consumed at each of the last four decennial periods:—

Years.	Total consumption.	Population.	Consumption per head.
1821	15,598,152 lb.	21,282,960	11.71 oz.
1831	19,533,841 "	24,410,439	12.80 "
1841	22,309,360 "	27,019,672	13.21 "
1851	28,062,841 "	27,452,692	16.86 " *

These numbers show that, during the last of these periods of ten years, the consumption of the United Kingdom increased one-fourth, or from 13½ to 17 ounces per head. But these last numbers do not truly represent the consumption in either of our two islands. Great Britain, as in the case of tea and ardent spirits, consumes a much larger proportional quantity than Ireland does. Thus, in 1853, the home consumption in the two countries was—

	Great Britain.	Ireland.
Total consumption	24,940,555 lb.	4,624,141 lb.
Consumption per head . . .	19 ounces	12 ounces

—being one-half greater in Britain than in Ireland.

The duty on tobacco is 3s. a lb., and its produce in the United Kingdom was, in

	Total duty.	Duty per head.
1852	£4,560,742	3s. 2d.
1853	4,751,760	3s. 4d.

In Europe, generally, the consumption is restricted by the heavy duties imposed upon it; yet the consumption of the United Kingdom is said to be less than that of most

* See an interesting paper by Mr. Crawford in the *Journal of the Statistical Society*, xvi., p. 50.

of the other European nations. In France it is about $18\frac{1}{2}$ ounces—three-eighths of this quantity being used in the form of snuff. In Denmark, it amounted, in 1848, to about 70 ounces, or $4\frac{1}{2}$ lb. per head; and in Belgium it averages at present $73\frac{1}{2}$ ounces, or $4\frac{3}{5}$ lb. per head.* These quantities are probably to some extent beyond the European average. But in some of the States of North America the proportion greatly exceeds these quantities; while among Eastern nations, where no duty is imposed upon tobacco, it is believed to be greater still. Mr. Crawford therefore estimates the average consumption of tobacco by the whole human race of 1000 millions at 70 ounces a head, and the total produce and consumption of this favourite narcotic at two millions of tons, or 4480 millions of pounds!† At 800 lb. an acre, this would require upwards of $5\frac{1}{2}$ millions of acres of rich land to be kept constantly under tobacco cultivation. The comparative magnitude of this quantity will probably strike the reader more forcibly when it is stated that the whole of the wheat consumed by the inhabitants of Great Britain—estimating it at a quarter a-head, or in round numbers at 20 millions of quarters—weighs only $4\frac{1}{3}$ millions of tons. The tobacco yearly raised, therefore, for the gratification of this one form of the narcotic appetite, weighs as much as the wheat consumed by ten millions of Englishmen. And reckoning it at only double the market value of wheat, or twopence and a fraction per pound, it is worth in money as much as all the wheat eaten in Great Britain!

* *Annuaire Statistique Belge*, 1854, p. 123.

† In New South Wales, where tobacco is free from duty, the average consumption, by recent official returns is about 14 lb. per head of the population,—three times as much as in Belgium. It is doubtful, however, if as large sums are now anywhere spent upon this indulgence as there were in England in the time of King James I., who says: "some of the gentry bestowing three and some four hundred pounds a yeere upon this precious stink."

The largest growers of tobacco at present are the United States of America. Their annual production, at the last two decennial periods of their census returns, was estimated in

1840	. . . .	at 219,163,319 lb.
1850	. . . .	„ 199,752,646 „

Being about one-twentieth part of the whole supposed produce of the globe.

2°. Varieties of Tobacco.—As many as forty species of the tobacco plant have been enumerated by some writers. The greater number of these are now, however, regarded as varieties, though eight or ten distinct species are still retained, of which different varieties are grown in different countries. Of the Virginian tobacco (*N. tabacum*) fig. 56, at least eight varieties are distinguished and named, and of the common green tobacco (*N. rustica*), fig. 57, there are probably as many more.

These facts possess an economical and chemical, as well as a botanical interest; for, on the one hand, the quality of the tobacco grown in the same locality, and in the same circumstances, differs with the variety of plant cultivated; and, on the other, the proportions of the chemical ingredients for which tobacco is distinguished likewise differ with the species or the variety.

Other circumstances also affect those sensible properties for which tobacco is prized. The climate, the soil, the mode of culture, the kind of manure applied, the period at which the leaves are gathered, the way in which they are dried and cured, the time they are kept in store, the distance to which they are carried to market,* and the process

* Well packed tobacco, like some wines, improves by a sea voyage. It undergoes by the way a species of fermentation, by which its flavour is mellowed. European tobacco is said to be much better when smoked in America than in its native Europe.

by which they are prepared for use—all these circumstances exercise a well-known influence upon the quality of the leaf. These conditions being so varied, there can be only few places in which they all conspire to the production of the most valuable crop. Hence, as is the case with the vine, and with the tea and coffee plants, the localities which yield tobacco in the greatest perfection are not only few in number, but generally very limited in extent.

The finest tobacco of America is produced in the island of Cuba. That of the island of Luzon, in the Philippines, from which the celebrated Manilla cigars are made, is nearly equal to that of Cuba. A fine but strong tobacco is produced in the province of Cadoe in Java, where it is grown in a naturally rich soil alternately with rice, and without manure. In Hindostan, a fine tobacco, known by the name of Bilsah, is grown in the province of Malwa, and in the province of Guzerat another fine variety, called Kaira. All these are the produce of the *Nicotiana tabacum*. In central Asia, the yellow tobacco of China and Thibet is peculiarly mild and agreeable, though, probably from its rarity, the inferior tobacco of India, when carried to Lhassa, sells as high as 30s. a pound—(Hooker). In western Asia, the most prized tobaccos are those of Latakia (the ancient Laodicea) in Syria, and of Shiraz in Persia. The former, like the Chinese tobacco, is the leaf of the *N. rustica*, the latter that of a species called *N. persica*. Thus the finest tobacco has a wide range of latitude, though the districts in which it is anywhere produced are, as I have said, very limited in extent. A warm summer appears to be necessary to the production of a delicately-flavoured leaf. That of temperate and cold regions is generally harsh and strong, as if it abounded more in the narcotic ingredients upon which the qualities of tobacco principally depend. How very much the mercantile values of the tobacco of

different countries differ from each other, may be judged of by the prices they bear as they are brought to the English market. These are very nearly as follows :—

Canada	4d. a pound.	Turkey	0s. 9d. a pound.
Kentucky	6d. "	Columbian	0s. 10d. "
Virginian	7d. "	Cuba	1s. 6d. "
Maryland	9d. "	Havannah	3s. 6d. "
St. Domingo	8d. "		

The commercial history of Dutch-grown tobacco is somewhat curious. In the valley of Guelderland—the Veluwe, as it is called—about two millions of pounds of tobacco are raised. Of this nearly one-half is bought by the French government for the supply of France. In that country it is used partly for cigars, and partly for making snuff. The rest of the Guelderland tobacco is shipped to North America, and even to Cuba. The fineness of the leaf, and its freedom from thick fibres, make it in request for the outer covering of cigars. In this case the market value of the tobacco is independent of its general quality or its chemical composition. Chinese tobacco is equally employed for covering cigars.

3°. Forms in which Tobacco is Used.—Tobacco is used in nearly all countries for each of the three purposes of chewing, smoking, and snuffing. The first of these practices is in many respects the most disgusting, and is now rarely seen in this country except among sea-faring men. On shipboard smoking is always dangerous and often forbidden, while snuffing is expensive and inconvenient, and less perfectly satisfies the narcotic appetite. If the weed must be used, therefore, the form of chewing is more excusable in the sailor.

In some of the southern and western states of North America, chewing to an offensive extent prevails; and in Iceland, according to Madame Pfeiffer, tobacco is chewed

and snuffed "with the same infatuation as it is smoked in other countries." The traveller in northern Sweden may have observed the *bunde* who accompanies or drives his post-horses, putting a large pinch of snuff from time to time into his mouth, thus applying to the wrong organ, as he conceives, the finely-powdered leaf. An Icelander applies the snuff to his nose, but in a peculiar manner. "Most of the peasants," says Madame Pfeiffer, "and even many of the priests, have no proper snuff-box, but only a box made of bone, and shaped like a powder-flask. When they take snuff they throw back the head, insert the point of the flask in the nose, and shake a dose of snuff into it. They then, with the greatest amiability, offer it to their neighbour—he to his; and so it goes round till it reaches the owner again."*

The box described in this passage is only a Highland horn *mull*, a little different in shape from those of modern fashion. The Highlander lifts the powder to his nose with a little shovel; the Icelander, using the small end of the horn, at once pours it in. But among the Celto-Scandinavians of northern Britain, there is the same love of the powdered tobacco as in Iceland and northern Scandinavia, and the same amiability in handing round the box as is seen in primitive Iceland. Are these not lingering relics of similar social customs, which still point to the ancient unity and common origin of the three now disconnected peoples? †

* Madame PFEIFFER'S *Visit to Iceland*, London edition, p. 179.

† I insert, in the form of a note, a reference to a use of tobacco, of which I can scarcely speak with confidence. It is said to be employed by unprincipled private brewers, in some parts of England, for adulterating beer, and by porter-sellers to adulterate porter. The country labourer who cannot afford of an evening to buy more than a single glass of beer, desires something for his little money which shall not only be tasty in his mouth, but also in a sensible degree affect his head. A few tobacco leaves, introduced after the manner of hops, are said to give this quality to the beer, and a little tobacco-extract to the porter. Several trustworthy persons, who profess to know, assure me that such a use of tobacco is by no means uncommon. How is it possible to protect the poor man against fraudulent persons, whom, by a morbid craving, he encourages to conspire against himself.

The practice of using snuff is said to have come into England after the Restoration, and to have been brought from France. The name of rappees (*rapés*), which we give to our moist snuffs, is certainly of French extraction, and a very large proportion of the tobacco now used in France is in the form of snuff.

For the smoker and chewer, tobacco is prepared in various forms, and sold under many names. The dried leaves, coarsely broken, are sold as canister or knaster. When moistened, compressed, and cut into fine threads, they form cut or shag tobacco. Softened with molasses, or with syrup, and pressed into cakes, they are called Cavendish or negro-head, and are used indifferently either for chewing or smoking. Moistened in the same way, and beaten until they are soft, and then twisted into a thick string, they form the pig-tail or twist of the chewer. Cigars are made of the dried leaves deprived of their midribs, sprinkled sometimes with a solution of saltpetre to make them burn better, and rolled up into a short spindle. When cut straight across, or truncated at each end, as is the custom at Manilla, they are distinguished as cheroots.

In preparing them for the snuff-taker, the dried leaves are sprinkled with water, laid in heaps, and allowed to heat and ferment from one to six months. During this fermentation a chemical decomposition takes place in the leaves, and they give off at first nicotin and ammonia,* and afterwards water and acetic acid. They are then reduced to powder, moistened with salt and water, and put into close boxes. Here they again heat and ferment. This gives them an agreeable ethereal odour and the well-known pungency of snuff. Rappees, or moist snuffs, are usually

* Ammonia is an invisible kind of air, or gas, which gives its smell to the hartshorn (liquid ammonia), and to the common smelling-salts (carbonate of ammonia) of the shops. It consists of the two gases, nitrogen and hydrogen.

prepared from the soft part of the leaves. Dried snuffs, like the Scotch and Welsh, are made from the fibres or midribs. The former are variously scented to suit the taste of the customer.

The quality and flavour of the snuff are materially affected by the variety of tobacco used—by the part of the leaf from which the snuff is formed—by the extent to which the two fermentations are carried—by the degree of heat at which the leaves are dried or roasted for dry snuffs—and by the length of time during which they are exposed to this heat. The kind of influence exercised by the fermentation and roasting will appear, when I shall have described the properties of the ingredients on which the activity of tobacco upon the human system depends.

4°. Effects of Tobacco.—In whichever of the three ways it is used, the effects produced by tobacco appear to be much the same in kind; they differ chiefly in degree. But, extensively as it is consumed, it is remarkable how very few persons can state distinctly the effects which tobacco produces upon them—the kind of pleasure which the daily use of it gives them—why they began, and for what reason they continue the indulgence. If the reader be a consumer of tobacco, let him ask himself these questions, and he will be surprised how little satisfactory the answers he receives will be. In truth, few have thought much on these points—have cared to analyse their sensations when under the narcotic influence of tobacco—or if they have analysed them, would care to tell truly what kind of relief it is which they seek in the use of it.

"In habitual smokers," says Dr. Pereira, a high authority in such matters, "the practice, when moderately indulged, provokes thirst, increases the secretion of saliva, and produces that remarkably soothing and tranquillising effect on the mind, which has caused it to be so much ad-

mired and adopted by all classes of society, and by all nations, civilised and barbarous." * Smoked to excess, and especially by persons unaccustomed to its use, it produces nausea, vomiting, in some cases purging, universal trembling, staggering, convulsive movements, paralysis, torpor, and death. Cases are on record of persons killing themselves by smoking seventeen or eighteen pipes at a sitting. With some constitutions it never agrees; but both Dr. Pereira, and Dr. Christison, in his *Treatise on Poisons*, agree that "no well-ascertained ill effects have been shown to result from the habitual practice of smoking." Dr. Prout, an excellent chemist, and a physician of extensive medical experience, whom all his scientific contemporaries held in much esteem, was of a different opinion. But even he expresses himself obscurely as to its being generally deleterious when moderately indulged in.†

The effects of chewing are of a similar kind; but the vapours which accompany the smoke of burning tobacco are more penetrating, and act more speedily than the juice which is squeezed from the leaf, as it is chewed, and occasionally turned over, in the mouth. Those of snuffing,

* *Materia Medica*, third edition, p. 1431.

† I give Dr. Prout's own words: "Tobacco disorders the assimilating functions in general, but particularly, as I believe, the assimilation of the saccharine principle. Some poisonous principle, probably of an acid nature, is generated in certain individuals by its abuse, as is evident from their cachectic looks, and from the dark and often greenish-yellow tint of the blood. The severe and peculiar dyspeptic symptoms sometimes produced by inveterate snuff-taking are well known; and I have more than once seen such cases terminate fatally with malignant disease of the stomach and liver. Great smokers, also, especially those who employ short pipes and cigars, are said to be liable to cancerous affections of the lips. But it happens with tobacco as with deleterious articles of diet, the strong and healthy suffer comparatively little, while the weak and predisposed to disease fall victims to its poisonous operation. Surely, if the dictates of reason were allowed to prevail, an article so injurious to the health, and so offensive in all its modes of enjoyment, would speedily be banished."

Yet reason is not so certainly on Dr. Prout's side; for Locke says: "Bread or tobacco may be neglected; but reason at first recommends their trial, and custom makes them pleasant."

also, are only less in degree. The same influence of tobacco, which, when the *quid* or the pipe is used, promotes the flow of saliva in the mouth, manifests itself, when snuff is taken, in producing sneezing, and in increasing the discharge of mucus from the nose. The excessive use of snuff, however, blunts the sense of smell, alters the tone of voice, and occasionally produces dyspepsia and loss of appetite. In rarer cases, it ultimately induces apoplexy and delirium.

It is chiefly because of "the soothing and tranquillising effect it has on the mind," as it is expressed by Dr. Pereira, that tobacco is indulged in. And were it possible, amid the teasing paltry cares, as well as the more poignant griefs of life, to find a mere material soother and tranquilliser, productive of no evil after-effects, and accessible alike to all —to the desolate and the outcast equally with him who is rich in a happy home, and the felicity of sympathising friends—who so heartless as to wonder or regret that millions of the world-chafed should flee to it for solace! I confess, however, that in tobacco I have never found this soothing effect. This, no doubt, is constitutional; for I cannot presume to ignore the united testimony of the millions of mankind who assert, from their own experience, that it does produce such effects. Its influence, indeed, appears very much to depend upon the constitution and natural temperament of the consumer. Among Europeans this is manifested chiefly by the difference of its effects upon different individuals, causing some to reject and avoid it, while others constantly and eagerly indulge in it. But in other countries, as in North America, the effects it produces separate, physiologically, entire regions from each other. The States of intellectual New England and New York, for example, taken as a whole, appear to dislike the use of tobacco; at least there is a very large, thinking, and con scientious body of men in these States, who are exerting

themselves to repress and suppress the use of the weed and who even desire a legislative enactment to prevent it The western and southern States, on the other hand, largely, and almost universally, indulge in tobacco; and one cannot travel from New York towards those States without coming in contact with the practices of smoking and chewing in their most offensive forms. In the one region the mass of thoughtful and religious men condemn the use of tobacco, chiefly, I believe, on moral grounds; in the other region, a vast majority of the mind, as well as almost universal practice, uphold and maintain it.*

These are very interesting physiological facts, well worthy of calm study on the part of those whose feelings will permit them to look at the matter coolly, and whose minds are capacious enough to take in and balance contradictory opinions and testimony. Climate gradually affects constitution and temperament. It has so affected, I believe, but in different ways, the two regions of North America to which I have referred. Upon constitutions and temperaments so diversely altered the constituents of tobacco act differently, and thus the broadest assertions, both of the abusers and of the defenders of tobacco in the several regions, may be strictly true, though decidedly opposed to each other, and entirely contradictory.†

Again, in New England, it is alleged as a strong moral argument against the use of tobacco, that it provokes thirst, and leads almost necessarily to excess in drinking, to frequent intoxication, and to all the evils which flow from it. This, which is sometimes alleged at home, and often with truth, is singularly at variance with its reputed effects among

* In Russia, the *Starovierze*, or "Old Believers," a very moral sect of dissenters from the Greek Church, look with horror on the use of tobacco —(De Lagny).

† There is much wisdom in the Irish form of equivocal assent to a doubtful assertion: "True *for you*"—meaning, "with my knowledge you would think differently."

the Asiatic nations. Mr. Lane, the translator of the *Arabian Nights*, says, that "being in a slight degree exhilarating, and at the same time soothing, and unattended by the injurious effects which proceed from wine, it is a sufficient luxury to many who without it would have recourse to intoxicating beverages." Mr. Layard, whose intercourse with Eastern nations has been most extensive, entertains the same opinion; while Mr. Crawford, who has also seen much of Eastern life, "thinks it can hardly be doubted that tobacco must, to a certain extent, have contributed to the sobriety both of Asiatic and European nations." *

These opposite facts form another interesting physiological study. In North America the smoking of tobacco provokes to alcoholic dissipation; in Asia it restrains the use of intoxicating drinks, and takes their place. How complicated are the causes out of which these different effects spring! Climate, temperament, bodily constitution, habits, and institutions, act and react upon each other; and according to the peculiar result of all these actions in this or that country, the same narcotic substance produces upon the mass of the people, a salutary, a harmless, or a baneful effect!

Generally of the physiological action of tobacco upon the bulk of mankind, and apart from its moral influences, it may be received as characteristic of this substance among narcotics—

First, That its greater and first effect is to assuage and allay and soothe the system in general.

Second, That its lesser and second, or after effect, is to excite and invigorate, and at the same time give steadiness and fixity to the powers of thought.

To what special action of its chemical constituents on the brain and nerves, the soothing action and the pleasing rev-

* *Journal of the Statistical Society*, March, 1858, p. 52.

erie, so generally spoken of, is to be ascribed, we can only guess. According to Dr. Madden, "the pleasure of the reverie consequent on the indulgence of the pipe, consists in a temporary annihilation of thought. People really cease to think when they have been long smoking. I have asked Turks repeatedly what they have been thinking of during their long smoking reveries, and they replied, 'Of nothing.' I could not remind them of a single idea having occupied their minds; and in the consideration of the Turkish character there is no more curious circumstance connected with their moral condition." *

Is it really a peculiarity of the Turkish or Moslem temperament, that tobacco soothes the mind to sleep while the body is alive and awake? That such is not its general action in Europe, the study of almost every German writer can testify. With the constant pipe diffusing its beloved aroma around him, the German philosopher works out the profoundest of his results of thought. He thinks and dreams, and dreams and thinks, alternately; but while his body is soothed and stilled his mind is ever awake. From what I have heard such men say, I could almost fancy they had in this practice discovered a way of liberating the mind from the trammels of the body, and of thus giving it a freer range and more undisturbed liberty of action. I regret that I have never found it act so upon myself.

5°. Chemical Constituents of Tobacco.—The active substances or chemical ingredients of tobacco or of tobacco smoke, those by which all its varied effects are produced, are three in number: a volatile oil, and a volatile alkali, which exist in the natural leaf—and an empyreumatic oil, which is produced during the burning of the tobacco in the pipe.

a. The volatile oil.—When the leaves of tobacco are

* *Travels in Turkey*, vol. 1. p. 16.

mixed with water and submitted to distillation, a volatile oil or fat comes over in small quantity. This fatty substance congeals or becomes solid, and floats on the surface of the water which distils over along with it. It has the odour of tobacco, and possesses a bitter taste. On the mouth and throat it produces a sensation similar to that caused by tobacco smoke. When applied to the nose, it occasions sneezing; and when taken internally, it gives rise to giddiness, nausea, and an inclination to vomit. It is evidently one of the ingredients, therefore, to which the usual effects of tobacco are owing; and yet it is remarkable, that from a pound of leaves only two grains of this fatty body are obtained by distillation. Upon such minute quantities of chemical ingredients do the peculiar action and sensible properties of some of our most powerful medicinal agents depend!

b. *The volatile alkali.*—When tobacco leaves are infused in water made slightly sour by sulphuric acid, and the infusion is subsequently distilled with quicklime, there comes over mixed with the water a small quantity of a volatile, oily, colourless, alkaline liquid, which is heavier than water, and to which the name of *nicotin* has been given. It has the odour of tobacco, an acrid, burning, long-continuing tobacco taste, and possesses narcotic and very poisonous qualities. In this latter respect it is scarcely inferior to prussic acid, a single drop being sufficient to kill a dog. Its vapour is so irritating, that it is difficult to breathe in a room in which a single drop has been evaporated. The proportion of this substance contained in the dry leaf of tobacco varies from 2 to 8 per cent.*

So far as experiments have been made, the tobaccos of

* The reader may recollect the great sensation produced in 1851 by the trial of the Comte de Bocarmé at Mons, and his subsequent execution, for poisoning his brother-in-law with nicotin.

Havanna and Maryland contain 2 per cent, that of Kentucky 6, that of Virginia nearly 7, and that of France from 6 to 8 per cent. It is rare, however, that a hundred pounds of the dry leaf yield more than seven pounds of nicotin. In smoking a hundred grains of tobacco, therefore—say a quarter of an ounce—there *may* be drawn into the mouth two grains or more of one of the most subtle of all known poisons. For as it boils at 482° F., and rises into vapour at a temperature considerably below that of burning tobacco, this poisonous substance is constantly present in the smoke. From the smoke of a hundred grains of slowly-burning Virginia tobacco, Melsens extracted as much as three-quarters of a grain of nicotin; and the proportion will vary with the variety of tobacco, the rapidity of the burning, the form and length of the pipe, the material of which it is made, and with many other circumstances.

c. The empyreumatic oil.—But besides the two volatile substances which exist ready formed in the tobacco leaf, another substance of an oily nature is produced when tobacco is distilled alone in a retort, or is burned as we do it in a tobacco pipe. This oil resembles one which is obtained in a similar way from the leaf of the poisonous fox-glove (*Digitalis purpurea*). It is acrid and disagreeable to the taste, narcotic and poisonous. One drop applied to the tongue of a cat brought on convulsions, and in two minutes occasioned death. The Hottentots are said to kill snakes by putting a drop of it on their tongues. Under its influence the reptiles die as instantaneously as if killed by an electric shock. It appears to act nearly in the same way as prussic acid.

The oil thus obtained consists of at least two substances. If it be washed with acetic acid (vinegar), it loses its poisonous quality. It contains, therefore, a harmless oil, and a poisonous alkaline substance which the acetic acid combines with and removes. The nature and chemical properties of

this alkaline poison have not as yet been investigated. The crude oil is supposed to be "the juice of cursed hebenon," described by Shakespeare as a distilment.*

Thus three active chemical substances unite their influences to produce the sensible effects which are experienced during the smoking of tobacco. All three are contained in variable proportions in the smoke of burning tobacco. The form and construction of the pipe, among other circumstances, influence, as I have said, the proportion of these ingredients which the smoke contains. Thus the Turkish and Indian pipes, in which the leaf burns slowly, and the smoke is made to pass gently bubbling through water, arrest a large proportion of the poisonous vapours, and convey the smoky air in a much milder form to the mouth. The reservoir of the German pipe retains the grosser portions of the oily and other products of the burning tobacco, and the long stem of the small Russian pipe has a similar effect. The Dutch and English clay pipes retain less; the metal (bronze or iron) pipes of Thibet (fig. 58), by becoming warm, bring still more of the constituents of the mild Chinese tobacco to the mouth of the smoker; while the cigar,

* The effects, real or imaginary, of this "juice," are thus described

"Sleeping within mine orchard,
My custom always of the afternoon,
Upon my secure hour thy uncle stole,
With juice of cursed hebenon in a vial,
And in the porches of mine ears did pour
The leperous distilment: whose effect
Holds such an enmity with blood of man,
That, swift as quicksilver, it courses through
The natural gates and alleys of the body:
And with a sudden vigour it doth posset
And curd, like eager droppings into milk,
The thin and wholesome blood: so did it mine;
And a most instant tetter bark'd about,
Most lazar-like, with vile and loathsome crust,
All my smooth body."—*Hamlet*, Act i. scene v.

especially if smoked to the end, discharges directly into the mouth of the smoker everything that is produced by the burning. Thus, the more rapidly the leaf burns and the smoke is inhaled, the greater the proportion of the poisonous substances which is drawn into the mouth. And finally, when the saliva is retained, the fullest effect of all the three narcotic ingredients of the smoke will be produced upon the nervous system of the smoker. It is not surprising, therefore, that those who have been accustomed to smoke cigars, especially of strong tobacco, should find any other pipe both tame and tasteless except the short black *cutty*, which has lately come in favour again among inveterate smokers. Such persons live in an almost constant state of narcotism or narcotic drunkenness, which must ultimately affect the health, even of the strongest. The chewer of tobacco, it will be understood from the above description, does not experience the effects of the poisonous oil which is produced during the burning of the leaf. The natural volatile oil and the nicotin are the substances which act upon him. These, from the quantity of them which he involuntarily swallows or absorbs, impair his appetite, and gradually weaken his powers of digestion.

Fig. 58.

Thibet pipe, tobacco-pouch and steel.
The pipe is of brass or iron, often with an agate, amber, or bamboo mouthpiece.

The same remarks apply to the taker of snuff. But his drug is still milder than that of the chewer. During the first fermentation which the leaf undergoes in preparing it for the manufacture of snuff, and again during the second fermentation, after it is ground, a large proportion of the nicotin escapes or is decomposed. The ammonia produced during these fermentations is partly the result of this decom-

position.* Further, the artificial drying or roasting to which tobacco is exposed in fitting it for the dry snuffs, expels a portion of the natural volatile oil, as well as an additional portion of the natural volatile alkali or nicotin. Manufactured snuff, therefore, as it is drawn up into the nose, and especially dried snuff, is much less rich in active ingredients than the natural leaf. Even the rappees, though generally made from the strongest Virginian and European tobaccos, containing 5 or 6 per cent. of nicotin, retain only 2 per cent. when fully manufactured.

I have already stated that in all the sensible properties by which the unadulterated leaf of the tobacco plant is characterised, the produce of different countries and districts exhibits important economical differences. All such diversities in quality and flavour, in strength, mildness, odour, &c., the chemist explains by the presence of the above-named active ingredients, sometimes in greater, and sometimes in smaller proportion; and it is interesting to find science in his hands first rendering satisfactory reasons for the long-established decisions of taste. Thus he has shown that the natural volatile oil does not exist in the green leaf, but is formed during the drying; hence the reason why the mode of drying and curing affects the strength and quality of the dried leaf. He has also shown that the proportion of the poisonous nicotin is smallest in the best Havannah, and largest in the Virginian and French tobaccos. Hence a natural and sound reason for the preference given to the former by the smokers of cigars, who receive directly into their mouths all the substances which escape from the burning leaf. And, lastly, by showing that both of the poisonous ingredients of

* Nicotin is one of those powerful vegetable principles which, like the *theine* of tea and coffee, are rich in nitrogen. Of this element it contains 17 per cent. It is from this nitrogen that the ammonia is formed during the decomposition described in the text.

tobacco are volatile, and tend to escape slowly into the air, he has explained why the preserved leaf, or the manufactured cigar, improves by keeping, and, like good wine, increases in value by increase of age.

As to the lesser niceties of flavour by which certain samples of tobacco are distinguished, these probably depend upon the presence of other odoriferous ingredients, not so active in their nature, or so essential to the leaf as those already mentioned. The leaves of plants, in respect to their odours, are easily affected by a variety of circumstances, and especially by the nature of the soil they grow in, and of the manures applied to them. Even to the grosser senses and less minute observation of Europeans, it is known, for example, that pig's dung carries its *gout* into the tobacco raised by its means. But the more refined organs and nicer appreciation of the Druses and Maronites of Mount Lebanon readily recognise by the flavour of their tobacco the variety of manure employed in its cultivation. Hence, among the mountains of Syria, and in other parts of the East, those samples of tobacco are held in the highest esteem which have been aided in their growth by the droppings of the goat.

6°. Adulterations of Tobacco.—But in countries where high duties upon tobacco hold out a temptation to fraud, artificial flavours are given by various forms of adulteration. "Saccharine matter (molasses, sugar, honey, &c.) which is the principal adulterating ingredient, is said to be used for the purpose of both adding to the weight of the tobacco, and of rendering it more agreeable to the taste. Vegetable leaves—as those of rhubarb, the beech, and the walnut—mosses, bran, the sproutings of malt, beet-root dregs, liquorice, Terra japonica, rosin, yellow ochre, fuller's earth, sand, saltpetre, common salt, sal-ammoniac"*—such

* Pereira's *Materia Medica*, 3d edition, p. 1427.

is a list of the substances which have been detected in adulterated tobacco. How many more may be in daily use for the purpose, who can tell? Is it surprising, therefore, that we should meet with manufactured tobacco possessing a thousand different flavours for which the chemistry of the natural leaf can in no way account?

Snuff has its own special adulterations, among which hellebore, to provoke sneezing, is the most deadly.

As substitutes for, or admixtures with tobacco, the leaves of different species of rhubarb, large and small, are collected in Thibet and on the slopes of the Himalaya. The long leaves of a Tupistra, called *Purphiok*, which yield a sweet juice, are also gathered in Sikkim, chopped up and mixed with the tobacco for the hookah—(DR. HOOKER). Other substitutes for genuine tobacco have been adopted in other countries, either from poverty or from taste. As a substitute for tobacco snuff, the powdered rusty leaves of the Rhododendron campanulatum are used in India, and in the United States of North America the brown dust which adheres to the petioles of the kalmias and rhododendrons. All these plants possess narcotic qualities. The Otomacs, a tribe of dirt-eaters in South America, also make a kind of snuff from the powdered pods of the *Acacia niopo*. This snuff throws them into a state of intoxication bordering on madness, and which lasts for several days. While under its influence the cares and restraints of life are forgotten, and dreadful crimes are perpetrated.

7°. TOBACCO AN EXHAUSTING CROP.—One other point in the chemical history of tobacco, though not connected with its narcotic influence upon the system, it may be proper here to notice. I have elsewhere explained* that when vegetable substances are burned in the open air, they leave unconsumed a portion of mineral matter or ash. The leaves of plants

* See THE PLANTS WE CULTIVATE.

are especially rich in this incombustible ash, and those of tobacco are among the richest in this respect among cultivated leaves. The dried tobacco-leaf, when burned, yields from 19 to 28 per cent of ash; or, on an average, every four pounds of perfectly dry tobacco contain one pound of mineral or incombustible matter. It is this which forms the ashes of our tobacco pipes and the nozzles of our burning cigars.

It is unnecessary here to describe in detail the composition of this ash, but I may remind my reader that all the substances it contains have been derived from the soil on which the tobacco plant was grown, and that they belong to the class of bodies which are at once most necessary to vegetation and least abundant even in fertile soils. In proportion, therefore, to the weight of leaves gathered must have been the weight of these substances withdrawn from the soil. And as every ton of perfectly dry leaves carries off four to five hundred-weight of this mineral matter—as much as is contained in fourteen tons of the grain of wheat—it will readily appear, even to those who are least familiar with agricultural operations, that the growing of tobacco must be a very exhaustive kind of cultivation. He will see in this, also, one main reason why tobacco plantations have in past times gradually become so exhausted as to be incapable, in many instances, of being longer cultivated with a profit—why once fertile lands are now to be seen lying waste and deserted—and why the fortunes of tobacco planters, even in naturally favoured regions, have gradually declined with the failing fertility of their wearing-out plantations. Upon the Atlantic borders of the United States of America the best-known modern instances of the effects of this exhausting tobacco-culture are to be found. It is one of the triumphs of the chemistry of the present century, that it has ascertained what the land loses by such imprudent treatment

whatever crop is grown—what is the cause, therefore, of the barrenness which befalls it—by what new management its ancient fertility may be restored, and thus how new fortunes may be extracted from the same old soil.*

* See the Author's *Lectures on Agricultural Chemistry and Geology*, 2d edition, p. 644.

CHAPTER XVI.

THE NARCOTICS WE INDULGE IN.

THE HOP, AND ITS SUBSTITUTES.

The hop; whence derived; when brought to England.—Consumption in the United Kingdom.—Produce of Belgium.—Importance of the hop.—Beauty of the hop grounds.—Management of the plant.—Properties which recommend its use in beer.—Varieties of the hop cultivated in England.—Qualities of the Farnham, Kent, North Clay, and Worcester hops.—Differences in estimation and flavour.—Soils on which they grow.—Chemical constituents of the hop flower.—The oil of hops.—The aromatic resin.—The lupuline grains.—The bitter principle.—Physiological action of the hop.—Difference between ale and beer.—Bitter substances used instead of the hop.—Cocculus indicus.—Singular qualities of this berry; its use in adulterating beer.—Poisonous picrotoxin contained in it.—Narcotic substitutes for the hop in South America, in India, and in China.—The Heetoo, Keesho, and Taddo of Abyssinia.—The marsh ledum used in Northern Europe.—Use of the yarrow, clary, and saffron.

II. The Hop—which may now be called the English narcotic—was introduced into this country at a comparatively recent period. It may have been employed in Germany in the times of the Roman writers, but was probably unknown to them. Its use, as an addition to malt liquor, appears to be of German origin. Hop gardens, by the name of Humolariæ, are spoken of in documents of the early part of the ninth century, and frequently in those of the

thirteenth century. In the breweries of the Netherlands the hop seems to have been introduced about the beginning of the fourteenth century. From the Low Countries, or, as some say, from Artois, which borders upon them, it was brought to England in the reign of Henry VIII., some time after his expedition against Tournay, and about the year 1524. In the twenty-second year of his reign (1530), that monarch, in an order respecting the servants of his household, forbad sulphur* and hops to be used by the brewers. Three quarters of a century later (1603) the introduction of spoilt and adulterated hops was forbidden by James I. under severe penalties. This appears to show that, though considerable attention is known to have been already given to the cultivation of the hop in England, a large part of the hops supplied to the home market was still brought from abroad.

1°. Consumption of the Hop.—At present, the hops consumed in the United Kingdom are almost entirely of home growth, and the consumption is very great. For the last four years the quantities retained for home consumption, and the amount of duty† paid into the revenue, amounted to—

Years.	Consumption.	Duty.
1850,	48,267,158 lb.	£232,576
1851,	26,138,906 „	129,580
1852,	50,146,639 „	244,866
1853,	30,949,590 „	152,677
Average,	38,875,573 „	£189,425

This average is supposed to represent as large a quantity of hops as is grown in all the world besides. How different a taste does this large consumption argue now from what

* This probably refers to the practice, which still prevails, of whitening or bleaching hops with fumes of sulphur, and which may not then have been so skilfully conducted as it is now.

† The duty is 18s. 8d. the cwt., and five per cent additional.

must have prevailed in the beginning of the seventeenth century, when the city of London petitioned Parliament against two nuisances—against Newcastle coals in regard of their stench, and against hops in regard they would spoil the taste of drink and endanger the people! * The produce of Belgium, which, for its population of 4½ millions, is one of the largest hop-growers in Europe, amounted in 1853 to 7,653,206 lb.

In Germany, Rhenish Bavaria and the Grand-duchy of Baden grow much hops, and of excellent quality; but the amount of the yearly produce I have no means of ascertaining. Holland grows little, and supplies itself in part by importations from the United States of North America.

In Russia, a variety of the hop grows wild in the Taurida, the Ural, and the Altai, but the principal supply is said to be imported from abroad.

The reason why the quantities retained for home consumption vary so much in the years above given, is that the crop is a very variable one, and that the crop of plenteous years is reserved to meet the demand of the less fruitful. An average consumption of about forty millions of pounds is very large; but the importance of this plant among the narcotics in which we indulge appears more clearly, when we compare the average consumption of it with that of tobacco. These are as follows:—

Hops, average consumption, . .	38,375,573 lb.
Tobacco in 1853, ...	29,737,561 „
	8,638,012 „

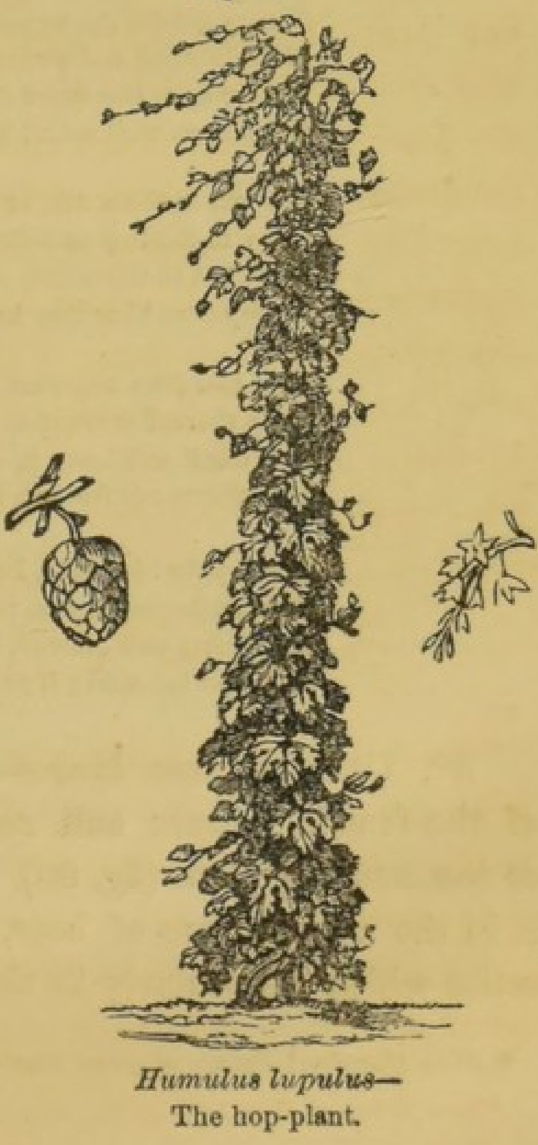
The yearly consumption of the hop exceeds, by two-sevenths of the whole, the home consumption of tobacco. It is the narcotic substance, therefore, of which England not only grows more and consumes more than all the world besides, but of which Englishmen consume more than they do of any other substance of the same class.

* See WALTER BLITH'S *English Improver Improved*, 3d edition, 1653.

And who that has visited the hop-grounds of Kent and Surrey in the flowering season will ever forget the beauty and grace of this charming plant? Climbing the tall poles, and circling them with its clasping tendrils, it hides the formality and stiffness of the tree that supports it among the exuberant profusion of its clustering flowers. Waving and drooping in easy motion with every tiny breath that stirs them, and hanging in curved wreaths from pole to pole, the hop-vines dance and glitter beneath the bright English sun—the picture of a true English vineyard, which neither the Rhine nor the Rhone can equal, and only Italy, where her vines climb the freest, can surpass.

2°. Cultivation of the Hop.—The hop "joyeth in a fat and fruitful ground;" as old Gerard wrote in 1596; "it prospereth the better by manuring." And few spots surpass, either in natural fertility or in artificial richness, the hop lands of Surrey, which lie along the outcrop of what are called the green-sand measures in the neighbourhood of Farnham. Naturally rich to an extraordinary degree in the mineral food of plants, the soils in this locality have been famed for upwards of two centuries for the growth of hops; and with a view to this culture alone, at the present day, the best portions sell as high as £500 an acre. And the *highest*

Fig. 59.



Humulus lupulus—
The hop-plant.

Scotch farmer—the most liberal of manure—will find him self outdone by the hop-growers of Kent and Surrey. An average expenditure of ten pounds sterling an acre for manure over a hundred acres of hops, farmed by a single individual, makes this branch of farming the most liberal, the most remarkable, and the most expensive of any in England.

This mode of managing the hop, and the peculiar value and rarity of hop-land were known very early. They form parts of its history which were probably imported with the plant itself. Tusser, who lived in Henry VIII.'s time, and in the reigns of his three children, in his *Points of Husbandry* thus speaks of the hop :—

> "Choose soil for the hop of the rottenest mould,
> Well-doonged and wrought as a garden-plot should:
> Not far from the water (but not overfloune),
> This lesson well noted, is meet to be knowne.
>
> The sun in the south, or else southlie and west,
> Is joy to the hop as welcommed ghest;
> But wind in the north, or else northerly east,
> To hop is as ill as fray in a feast.
>
> Meet plot for a hop-yard, once found as is told,
> Make thereof account as of jewel of gold;
> Now dig it and leave it, the sun for to burne,
> And afterwards fense it, to serve for that turne.
>
> The hop for his profit, I thus do exalt:
> It strengtheneth drink, and favoureth malt;
> And being well brewed, long kep it will last,
> And drawing abide, if ye draw not too fast." *

3°. Uses of the Hop.—The hops of commerce consist of the female flowers and seeds of the *Humulus lupulus*, or common hop-plant (fig. 60). Their principal consumption is in the manufacture of beer, and they possess three properties which particularly fit them for this use. First, They

* *Five Hundred Points of Good Husbandry.* London edition of 1812, p. 167.

impart to malt liquors a pleasant, bitter, aromatic flavour, and tonic properties. Second, They give them a peculiar *headiness*, often confounded with alcoholic strength, and thus save to the brewer a certain proportion of his malt. The soporific quality of beer, also, is ascribed in part to the narcotic quality of the hop. Third, By their chemical influence they clarify malt liquors, and check their tendency to become sour. They arrest the fermentation at the alcoholic stage; and it appears, from the history of the art of brewing, that beer which could be kept for a length of time has only been manufactured in England since the hop has been introduced. "The ale," says Parkinson (1640), "which our forefathers were accustomed only to drink, being a kind of thicker drink than beere, is now almost quite left off to be made, the use of hoppes to be put therein altering the quality thereof, to be much more healthful or rather physicall, to preserve the body from the repletion of grosse humours which the ale engendereth."

Fig. 60.

Humulus lupulus—The common hop. The upper is the male plant and flower: the lower is the female flower.

4°. Varieties of the Hop. — Of the cultivated hop there are many varieties; but in our principal English hop-districts, Kent, Surrey, and Sussex, only about five varieties are extensively grown. These are—

First. The *goldings*, grown chiefly in middle and east Kent. They delight in a rocky, calcareous soil, or a rich

friable loam. They thrive only in the most naturally fertile kinds of soil.

Second. The *white-bines* are the favourites of Farnham and Canterbury. They require the same description of soil as the goldings, are very similar in their appearance and growth, and have nearly the same value in the market. The flower of the white-bines is considered to possess the most delicate flavour, while that of the goldings is thought by some brewers to have more strength.

These two varieties are most esteemed for the brewing of pale bitter ale. They both require very long poles, and on the average of years produce smaller crops and a coarser kind of hop.

Third. The *Jones's* stand next in favour with the brewer. They will grow on inferior land; and as they require very short poles, and are pretty good croppers, they are in general favour with many growers in Kent.

Fourth. The *grape* has many sub-varieties, and requires longer poles than the Jones's. This variety delights in stiff heavy soils, after thorough drainage, and produces very heavy crops. Hence its prevalence in the Weald. It is commonly used for the ordinary sorts of beer.

Fifth. The *colegate* is a smaller variety of hop than the grape, but produces enormous crops in Sussex and the Weald of Kent. It is often surreptitiously passed off in the market as goldings; but is greatly disliked by the brewers on account of the rankness of its flavour. It is looked on by many as the worst hop that is grown.

From the kind of soil on which they grow, these two varieties are also known by the name of *clay hops*. Those which are raised in the Weald of Kent and Sussex, should, I suppose, be called *south clay hops*, as those which grow on the stiff clays of Nottinghamshire are known in the market as the *north clays*.

From this brief description of the more common varieties of this plant, it will be understood that a great diversity of flavour and quality must prevail among the hops, not only of different districts, but even of the same county. Thus the county of Kent produces hops of various degrees of excellence, the best samples combining in an eminent degree the qualities of flavour and strength. The soils of this county rest chiefly on the chalk, but partly, also, on its south-west border, on the green-sand formation. Its northern part is covered by the tertiary beds of the London basin; and it is around Rochester and Canterbury, where the clays of these tertiaries and the porous chalks meet, hat the best Kent hops are grown. Inferior samples grow on the clays of the Kentish Weald.

In Surrey, again, the hops of the neighbourhood of Farnham have from time immemorial borne the highest price in the British hop-market. They grow on the marly soils rich in phosphate of lime, which are formed from the rocks of the green-sand formation; and so much does their excellence depend upon the natural quality of the soil, that the value of the crop changes sometimes on the mere crossing of a hedge. The change of quality in the soil in this locality is often sharp and sudden, and hence the equally sudden change in the quality of the crops it produces.

The clay hops of Kent and Sussex are coarse and rank, but those of the small district of Retford in Nottinghamshire, called the *north clays*, are preëminent in rankness. They give a coarse flavour to beer, which is almost nauseous to those who are unaccustomed to it. The stiff clays of the county of Nottingham, on which these hops grow, lie in the valley of the Trent, and are formed chiefly from the debris of the new red sandstone, through which the Trent flows, with admixtures from the coal measures, magnesian limestone, and lias clay brought down by the feeders of the Trent.

Probably a more thorough drainage of this district would improve the quality of its hops.

To those who are accustomed to the mild flavour of the Kent hops, that of the north clays is almost nauseous. But the Kent hops, again, are disrelished by those who have been accustomed to the still milder flavour of the Worcester hops. These excel in this respect the best Kent goldings, and are usually very taking to the eye. In practice, they are found to ripen beer sooner than any other variety of hop. They grow on the red soils of the vale of Severn, and, in the opinion of beer-drinkers, possess a grateful mildness not to be found in any other hops. Hence, in Lancashire, Cheshire, and some other counties, where the taste for the Worcester hops exists, even fine Kent hops would be rejected as unsaleable. A nice Lancashire beer-drinker calls beer hopped with Kent hops *porter ale.* They do not answer, however, for the best descriptions of malt liquour, such as the pale ale, because they do not impart so fully the keeping quality.

The red soils of Worcestershire are formed from the debris of the new red sandstone, sifted and sorted by the waters of the Severn. The traveller passes through part of this hop region on his way from Worcester to Malvern. The red soils of Hereford, on which also hops are largely grown, are derived from the old red sandstone, and in mildness of quality the hops they yield are, I believe, similar to those of Worcester. Rich, open, and friable, these red soils so far resemble those of Kent and Surrey, from which the Canterbury and Farnham hops are gathered. The variety of hop grown in this region differs, however, from those of Kent and Surrey. It is supposed to be a descendant of the Flemish red-bine.*

* The proportions in which these several kinds of hops are grown and used in

Thus the soil or locality in which they are grown, and the variety raised, have much influence upon the flavour which the hops will impart to beer. But besides these, the time of picking, the mode of drying and curing, the care bestowed on the bagging, the place in which they are afterwards kept, and the length of time they have been gathered, all affect the finer qualities of the hop flower. And, if to these we add the numerous minute variations which occur in the process of brewing, from time to time, even in the same establishment, it will no longer appear surprising that a very great variety of flavours should be given to beer by the use of hops alone.

5°. Active Ingredients of the Hop.—In so far as such diversities of flavour depend upon the quality of the hop itself—and not upon the quality of the water employed, which much affects the flavour of beer—they are probably due, as in the case of tobacco, to the different proportions in which the active chemical ingredients of the flower exist in the several samples. These active ingredients, in so far as is yet known, are three in number—a volatile oil, a slightly aromatic resin, and a bitter principle.

a. The volatile oil.—When hop flowers are distilled with water, they yield as much as 8 per cent of their weight

England may be judged of by the amount of duty paid by those of each locality in 1852 and 1853.

	1852.	1853.
Rochester	£97,174	£61,085
Canterbury	52,746	33,628
Kent	149,920	94,713
Sussex	63,654	38,668
Worcester	12,625	11,283
Farnham	16,311	6,909
North clays, ...	942	225
Essex, ...	1,200	807
Sundries, ...	210	69
	£244,862	£152,674

of a volatile oil. This oil has a brownish-yellow colour, a strong smell of hops, and a slightly bitter taste. In this oil of hops it was supposed that a portion of the narcotic influence of the flower resided. Recent experiments render this opinion doubtful. The raw oil is a mixture of two volatile oils, and sometimes exhibits narcotic properties. When rectified, these properties disappear. It seems probable, therefore, that in the case both of tobacco and of the hop, a minute but variable proportion of a volatile narcotic substance distils over along with the oil, and that to this other substance the oil owes the narcotic qualities it sometimes exhibits. The nature of this volatile narcotic body has not been examined.

The hop has long been celebrated for its sleep-giving qualities. To the weary and worn, the hop pillow has often given refreshing rest, when every other sleep-producer had failed. It is to the escape of the volatile narcotic ingredient above mentioned, in minute quantity from the flowers, that this soporific effect of the hop is most probably to be ascribed.

Upon the same volatile ingredient depends the odour which is perceived in store-rooms where hops are kept, and much of the aroma they impart to beer. It is owing to the escape of this ingredient, even from the most closely-pressed hops, that they deteriorate in quality so much by keeping, as usually to fall one-third in value when upwards of a year old. By boiling in the wort, also, a portion of the same delicate aromatic principle is driven off and lost to the beer.

b. The aromatic resin.—When dry hop-flowers are beat, rubbed, and sifted, a fine yellow dust separates from them, which is equal in weight to about a sixth part of that of the hops. This fine powder is sometimes distinguished by the name of *lupulin.* Hop-buyers talk of it as the "condition" of the hop. Under the microscope the powder is seen to

consist of minute, somewhat transparent, grains or glands of a rounded form, a golden-yellow colour, and a cellular texture. By drying they lose their round form (see fig. 61), and when put into water they give out an immense number of minute globules. The function of these organised lupulinic glands, as a part of the plant, is involved in much obscurity. They possess a strong agreeable odour, and a bitter taste. When taken internally they are aromatic and tonic. They soothe, also, and tranquillise, allay pain, reduce the pulse, and in a slight degree provoke sleep. Alcohol extracts from them, and dissolves out more than half their weight of a reddish-yellow transparent resin, which is slightly aromatic, but when pure is not at all bitter. This is the aromatic resin of the hop-flower, of which it forms one-twelfth part, or 8 per cent. by weight. What share this resin has in producing the effects which follow from swallowing the entire grains, is not satisfactorily known.

Fig. 61.

Dried lupuline grains greatly magnified—showing
a. Granules in the interior.
b. The hilum or point of attachment to the flower.

c. The bitter principle.—Besides the resin, the little grains contain 2 per cent. of a volatile oil, 2 per cent. of tannin, and 10 per cent of a peculiar bitter principle. This last is the best-known constituent of the hop, and gives bitterness to our beers. In the other parts of the flower, also, there exists a bitter ingredient, upon which few accurate experiments have been made. The bitter matter of the grains is said not to be narcotic, but what is its true action on the system is not known. The tannin helps to clarify the beer.

But though the specific action of each of the chemical principles contained in the hop flower has not been very well ascertained, the united action of all of them together is well known. The tinctures and extracts of hops which we

use in medicine, and introduce into our beers, contain them all, so that all the virtues of the hop, in whichever of the ingredients it resides, are present in them in a greater or less degree. Hence well-hopped beer is aromatic, tonic, soothing, tranquillising, and in a slight degree narcotic, sedative, and provocative of sleep. The hop also aids in clarifying malt liquors, arrests the fermentation before all the sugar is converted into alcohol, and thus enables them to be kept without turning sour.

Ale was the name given to unhopped malt liquor before the use of hops was introduced. This is alluded to in the passage already quoted from Parkinson, and in the two old lines—

> " *Hops*, reformation, bays and *beer*
> Came into England all in one year."

The words of Gerard, also, show the original meaning of the two words. " The manifold virtues in hops do manifestly argue the wholesomeness of *beer* above *ale;* for the hops rather make it physicall drinke, to keep the body in health, than an ordinary drink for the quenching of our thirst." When hops were added, it was called beer by way of distinction; I suppose, because we imported the custom from the Low Countries, where the word beer was still in use.*

* This word is found both in the new and old dialects of the high and low German, Dutch, and Flemish, in the form of *bier*. In France it is *bière*, and in Italy *birra*. In these latter countries it has superseded the old word *cervoise*, still used in Languedoc; *cervogia*, still heard in Italy—both of which, like the Spanish *cerveza*, are from the Latin *cervisia*, a word used by Pliny for a drink made from malt.

In Anglo-Saxon it was *beor;* in new and old Norsk, *bior;* in Gaelic, *beóir;* in Breton, *ber* or *bier;* and the Bretons are said by Tacitus to have made a sort of wine from barley which they called *baer*.

But this word for the drink disappeared from England, and ale took its place, till it was brought in again to denote *hopped* ale, a sense which it did not originally bear. It disappeared also from the Welsh, whose name for beer is *cwrw*. But though it has penetrated into France and Italy, *öl* is still the only word in use in Scandinavia. The Scandinavian name, which prevailed among us after the Romans left, points, like so many other relics, to the race which has chiefly predominated in the Island since.

Ground ivy (*Nepeta glechoma*) called also *alchoof* and *tun-hoof*, was generally employed for preserving ale before the use of hops was known.

To the general reader it may appear remarkable—perhaps he may even think it a reproach to science—that the chemistry of a vegetable production in such extensive use as the hop should still be so imperfect, our knowledge of its nature and composition, and of the special physiological effects of its several constituents, so unsatisfactory. But the well-read chemist, who knows how wide the field of chemical research has become, how rapidly our knowledge of it as a whole is progressing, and who endeavours in his daily studies to keep up with that progress,—he will feel no surprise. He must wish, indeed, to see all such obscurities and difficulties cleared away; but he will feel more inclined to thank and praise the many ardent and devoted men who in every country are now labouring in this department, and to encourage them in what they are doing, than to blame or reproach them for being obliged to leave a part of the extensive field for the present uncultivated.

The hop, as we have seen, is to be placed among the most largely-used narcotics, especially in England. It differs, however, from tobacco and the other favourite narcotics to be hereafter mentioned, in being rarely employed alone except medicinally. It is added to infusions like that of malt, to impart flavour, taste, and narcotic virtues. Used in this way it is unquestionably one of the sources of that pleasing excitement, gentle narcotic intoxication, and healthy tonic action, which well-hopped beer is known to produce upon those whose constitutions enable them to drink it. Other common vegetable productions will give the bitter flavour to malt liquors. Horehound, wormwood, gentian, quassia, camomile, fern leaves of different species, broom tops, ground ivy, common gale, the bark of the box-tree,

dandelion, chicory, orange peas, picric acid, chirayta, the poisonous strychnia,* and many other substances, have been employed or recommended in England, to replace or supplant the use of the hop. But none of these are known to approach it in imparting those peculiar properties which have given the English bitter beer of the present day its high reputation.

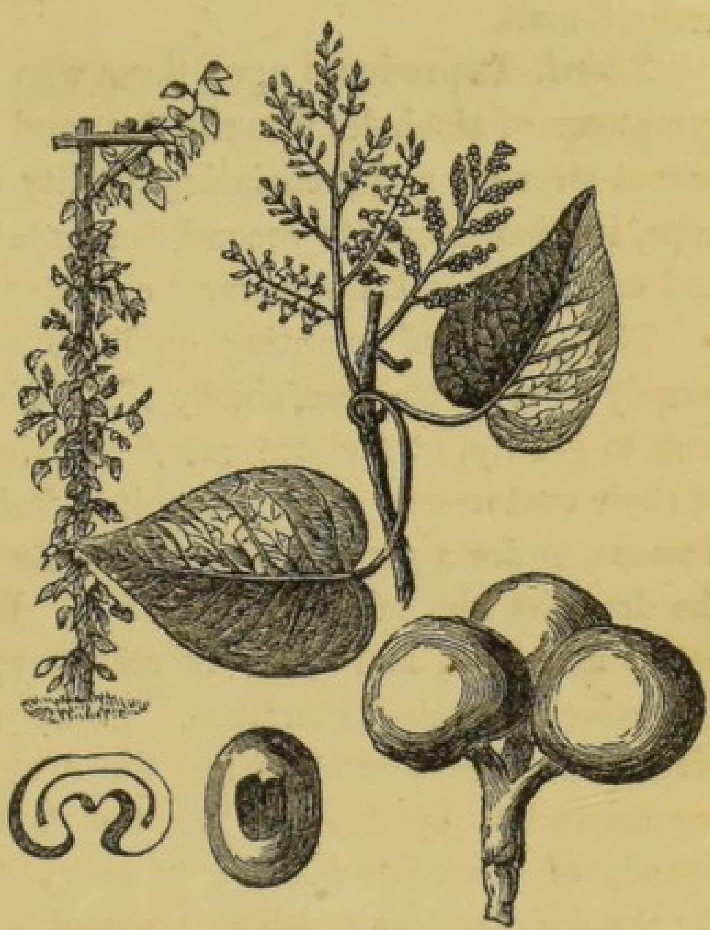
It is interesting to observe how men carry with them their early tastes to whatever new climate or region they go. The love of beer and hops has been planted by Englishmen in America. It has accompanied them to their new empires in Australia, New Zealand, and the Cape. In the hot East their home taste remains unquenched, and the pale ale of England follows them to remotest India. Who can tell to what extent the use of the hop may become naturalised, through their means, in these far-off regions? Inoculated into its milder influence, may not the devotees of opium, and the intoxicating hemp, be induced hereafter to abandon their hereditary drugs, and to substitute the foreign hop in their place? From such a change in one article of general consumption, how great a change in the character and habits of the people might we not anticipate?

III. Cocculus Indicus can scarcely be classed among the narcotics in which we voluntarily indulge, and yet it is one which our humbler beer-drinkers involuntarily consume to a very considerable extent. It is the fruit or berry of the *Anamirta cocculus* (fig. 62), a beautiful climbing-plant, which is a native of the Malabar coast and of the Indian

* Strychnia is an intensely bitter substance contained in nux vomica; chirayta, an intensely bitter plant from India; and picric acid, an almost equally bitter substance produced by the action of nitric acid upon indigo. The latter two have only recently been tried for giving bitterness to beer. The first is too poisonous for any but very reckless people ever to recommend. It is so bitter that its taste can be detected when dissolved in 600,000 times its weight of water.

Archipelago. It is sometimes called the Levant nut, or the *Bacca orientalis.* It has some resemblance to the bay berry, and in 1850 was imported into this country to the extent of 2,359 bags, of one hundredweight each. It is chiefly used for adulterating cheap beer, and it is really wonderful in how many ways this singular substance is fitted to aid the dishonest brewer in saving both malt and hops. I mention three of its properties which offer temptations too strong to be resisted by many unscrupulous people.

Fig. 62.



Anamirta cocculus—The Cocculus indicus plant.

If the bruised seeds are digested in water, they yield an extract which, when added to beer, produces the following effects:—

First. It imparts to it an intensely bitter taste, and can thus be substituted cheaply for about one-third of the usual quantity of hops, without materially affecting the flavour of the beer.

Second. It gives a *fulness* and richness in the mouth, and a darkness of colour, to weak and inferior liquors. In these respects, a pound of *Cocculus indicus* is said to be equivalent to a sack (four bushels) of malt. Or to a thin

brewing of beer, a pound of this drug will give an apparent substance equal to what would be produced by an additional sack of malt.

Third. It produces upon those who drink it some of the symptoms of alcoholic intoxication, and thus adds to the apparent strength and inebriating quality of the liquor. Like hops, it also prevents second fermentation in bottled beer, and enables it to keep in warm climates.

This array of tempting qualities causes it to be used largely by some brewers, chiefly of the disreputable class, who seek to gratify, at a cheap rate,* certain wishes and desires of their customers. The use of it is forbidden by act of Parliament, under a penalty of £200 to the brewer, and £500 to the druggist who sells it to a brewer. But an extract is prepared and sold, and there is reason to believe that it is extensively used—(PEREIRA). Some writers on brewing give plain directions for using the drug; and the quantity recommended by Morrice to the honest brewer (!) is 3 pounds of *Cocculus indicus* to every 10 quarters of malt. By the dishonest, as much as 1 pound is sometimes added to the barrel of 54 gallons, with *Calamus aromaticus* and orris root to flavour it. If 1 pound really save 4 bushels of malt, the 2,359 cwt. imported in 1850, if all employed for this purpose, must have saved to the adulterators who used it the enormous quantity of 1,056,000 bushels!

It is chiefly the humbler classes upon whom this fraud is practised. The middle classes in England prefer the thin wine-like ales and bitter beers. The skilled labourer prefers what is rich, full, and substantial in the mouth; and the poor peasant, after his day's toil, likes to find at the bottom of his single pot what will sensibly affect his head. It is thus chiefly among the working men that the heavy drugged beer of the adulterator is relished and consumed; and it is

* It is sold at 19s. to 21s. a hundred weight, or 2¼d. a pound.

probable that something of the peculiarly beastly forms of intoxication sometimes seen among these classes is to be ascribed to the influence of *Cocculus indicus.*

The effects which this substance produces are said, by those who have drunk beer drugged with it, to be more upon "the voluntary muscles than upon the intellectual powers."* If so, a man under its influence may be surprised by finding his body helpless while his mind is comparatively clear, and still capable of reasoning and judging with tolerable correctness. Others say, however, that its effect is chiefly on the brain, so that its mode of action probably varies in some degree with the constitution of the individual who takes it.

In large doses it is poisonous to all animals, and a well-known use of it is for the stupefying of fish.† Although, therefore, its special effects upon the human constitution have not been accurately ascertained by the scientific physiologists, the frequent use of *Cocculus indicus*, even in small doses, can scarcely fail sooner or later to injure the health.

This poisonous quality is derived chiefly from a white crystalline intensely bitter substance called *picrotoxin*, which exists in the inner portion of the berry. The way in which this poisonous ingredient acts upon the system is still involved in considerable obscurity; but there cannot be a doubt as to the moral criminality of introducing substances of so dangerous a kind into the common drink of the least-protected part of the people.

* Pereira, *Materia Medica*, 3d edition, page 2155.

† In India, the bruised leaves of *Phyllanthus conami*, and the capsules of the *Xanthophyllum hastile* (Lindley), and on the Himalayas the seeds of the Chaubmoogra, and the fruit of the evergreen Took, or Hydrocarpus, are used for intoxicating fish—(Hooker). The bruised root of the *Randia dumetorum* has a similar effect—(Roxburgh). I am not aware that any of these is ever administered to man. The Indians of South America use bruised Angostura bark to intoxicate fishes—(Hancock); and the Peruvians make the same use of Cinchona bark (Saunders).

IV. Other substitutes for the Hop.—Other narcotic substances more or less powerful are in different countries substituted occasionally for the hop. And, like Cocculus indicus, the most injurious of these substitutes are generally introduced into the liquor without the knowledge of the drinker. Thus—

1°. *In South America* the bitter stalks of the *Schinus molle* are mixed with the chica, which is prepared by chewing the sweet pods of the *Prosopis algaroba.** What is the action of this bitter substance on the drinker of the chica is not stated.

2°. *In India*, when the raw cane-sugar (jaggery) is fermented with a view to the distillation of rum, chips of the dried bark of the *Acacia ferruginea* or *A. leucophlea*, are added to the liquor. It is supposed to act like hops in moderating the fermentation, and probably gives a flavour and other peculiar qualities to the rum distilled from it, but it is not known to be added with a view to any narcotic effects. The rum itself is described by Buchanan as being execrable.†

3°. *In China* a kind of beer, called *tar-asun*, is made from barley or wheat. In brewing this beer, a prepared hop is added to the wort, which both causes fermentation and performs at the same time the duties of the hop. Of what this preparation consists my authority does not say.‡

4°. *In Africa.*—In preparing their hydromel, or mead, the Abyssinians add to the solution of honey a portion of a bark called *heetoo.* The leaves and fruit of the tree from which this bark is taken are narcotic and poisonous. It is probable, therefore, that the bark, which is described as bit-

* See The Liquors we ferment, p. 250.

† *Journey through the Mysore*, vol. 1, p. 39.

‡ Morewood *On Inebriating Liquors*, p. 120.

ter, astringent, and tonic, may also possess a portion of the same narcotic virtue, and impart it to the mead.

The leaves of a tree called *keesho* are likewise used in Abyssinia for mixing with mead,* but it is not stated if they possess narcotic properties. Other travellers speak of a root called *taddo* as being in common use among Ethiopian tribes, as an addition to the mixture of malted barley and honey of which their favourite drink is made. But nothing is known of the chemical history of these and the other substances.

5°. *In Northern Europe.*—The *Ledum palustre* (the marsh ledum, or wild rosemary), fig. 63, a heath-plant common in the north of Europe, was formerly used in Sweden and North Germany for giving bitterness and apparent strength to malt liquors. Its leaves, when infused in the wort, render the beer unusually *heady*, so as to produce headaches, nausea, and even delirium, when drunk to excess. In Germany the use of it for this purpose is now forbidden by law. Like Cocculus indicus among ourselves, however, it is said† to be still used extensively by fraudulent brewers in the northern part of that country, to give a dangerous intoxicating power to their beer. When and how shall the poor and the ignorant find shelter from knowing fraud?

Fig. 63.

Ledum palustre—The marsh Ledum, or Labrador Tea.
The undermost flower and leaf represent those of
Ledum latifolium—The Labrador Tea, or broad-leafed Ledum.
Scale, 1 inch to 2 feet.
Leaves and flowers nearly natural size.

* HARRIS's *Highlands of Ethiopia.*

† BECKWITH's *History of Inventions* (Bohn's edition), vol. ii, p. 385.

The *Ledum latifolium* possesses similar narcotic proper ties, and, where it occurs in sufficient abundance, is used instead of, or along with the *palustre.*

In North America, both these plants are known by the name of Labrador tea, and are used as substitutes for Chinese tea. Both are very astringent; and, in addition to the tannic acid to which this property is due, probably contain also a narcotic principle not yet examined. To this narcotic principle both the qualities which fit these plants to be used in cold climates as a substitute for tea, and those which enable it to impart intoxicating properties to beer, are to be ascribed. According to Dr. Richardson, the narrow-leafed *L. palustre* is the better suited of the two for the making of tea.* Both plants would probably well repay a detailed chemical examination.

The leaves of yarrow or millefoil (*Achillea millefolia*) have the property of producing intoxication. These are also used in the north of Sweden by the Dalecarlians to give headiness to their beer.

6°. *In England*, clary (*Salvia sclarea*) is said to give an intoxicating quality to beer. Saffron, also, the dried stigmas of the *Crocus sativus*, has a similar effect. It exercises a specific influence on the brain and nerves, and when taken in large doses, causes immoderate mirth and involuntary laughter. Its exhilarating qualities are so remarkable that it has been supposed to be the *nepenthes* of Homer; and to denote a merry temper it became a proverb, "Dormivit in sacco croci"—(he has slept in a saffron bag). It has the singular property also, of counteracting the intoxication produced by alcoholic liquors, as hops to some extent do. This was known to Pliny, who says that it allays the fumes of wine and prevents drunkenness. "It was therefore taken in drink by great wine-bibbers, to enable

* See The Beverages we infuse, p. 159.

them to drink largely without intoxication."* Its effects, however, are very uncertain, and it is now little used in medicine, and still less, I believe, for adulterating beer.

* For much more on saffron, see PHILLIPS' *History of Cultivated Vegetables* vol. ii, p. 180.

CHAPTER XVII.

THE NARCOTICS WE INDULGE IN.

THE POPPY AND THE LETTUCE.

The poppy, ancient and modern use of.—Preparation of opium.—Mode of collecting.—How opium is used.—Effects of opium.—It sustains the strength.—Delightful reveries produced by.—De Quincey's experience.—That of Dr. Madden.—Final results of opium indulgence.—Seductive influence of opium.—Case of Coleridge.—Impotence of the will under its influence.—Difficulty of giving it up.—Bodily and mental tortures in doing so.—Extent to which opium is used.—Produce and consumption in India and China.—Consumption in Great Britain.—Its use as an indulgence in this country.—Drugging of children, and its effects.—Chemical constituents of opium.—Properties of morphia.—Little known of the true action of opium.—Average composition of opium.—Varieties in its strength.—Proposed opium culture in France.—Influence of the variety of poppy on the proportion of morphia.—Morphia not so poisonous to inferior animals.—Dilution of opium in India and Java.—Influence of race in modifying the effects of opium.—The Javanese, the Malay, the Negro.—Corrosive sublimate eaten with opium.—Effects of opium compared with those of wine.—Is opium necessarily deleterious.—Dr. Eatwell's testimony.—Practical conclusions.—Substitutes for opium.—Bull-hoof.—The lettuce, lactucarium and lactucin; resemblance to opium in properties and physiological effects.—Syrian or Steppe rue; its uses in the East as a narcotic indulgence.

V. The Poppy.—The use of the common white poppy (*Papaver somniferum*), fig. 64, as a soother of pain and a giver of sleep, has been familiar from the earliest periods. This is partly shown by the names *poppy* in English, and

papaver in Latin—which are said to have been given to the plant because it was commonly mixed with the food of young children (pap or papa) to ease pain and secure sleep. In this country, the chief use of the poppy is as a medicine.

In the East, however, it is used as an exhilarating narcotic. The Tartars of the Caucasus, who, though professedly Mahomedans, drink wine publicly, make it very heady and inebriating, by hanging the unripe heads of poppies in the casks while the fermentation is going on. A decoction of poppies, also called *koke-maar*, is sold in the coffeehouses of the Persian cities, where it is drunk scalding hot, and produces amusing effects. As it begins to operate, the drinkers quarrel with and abuse each other, but without coming to blows; and afterwards, as its effect increases, make peace again. One utters high-flown compliments, and another tells stories; but all are extremely ridiculous both in their words and actions —(Tavernier).

Fig. 64.

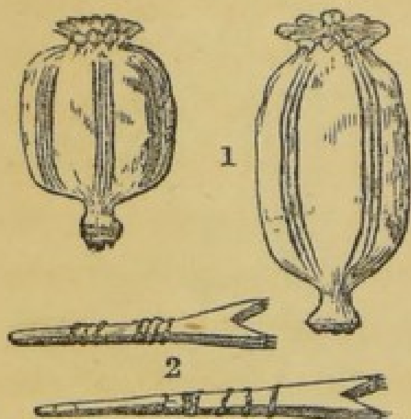
Papaver somniferum—Common white Poppy. Scale, 1 inch to the foot.

1°. Preparation of Opium.—But it is the dried or concrete juice of the poppy head that is generally and extensively employed as a narcotic indulgence. This dried juice is called by the Persians *afioun*, and by the Arabs *afioum*, and hence our European name *opium*.

This important drug is obtained by making incisions into

the capsules or seed-vessels of the poppy plant when they are nearly ripe, allowing the milky juice which exudes to thicken upon the capsules for twenty-four hours, and then scraping it off. The incisions are made downwards through the outer skin only. For this purpose a small knife, called a Nushtur, is used, which consists of three or four minute blades fastened together (fig. 65). These knives make as many parallel incisions, which allow the juice freely to escape.

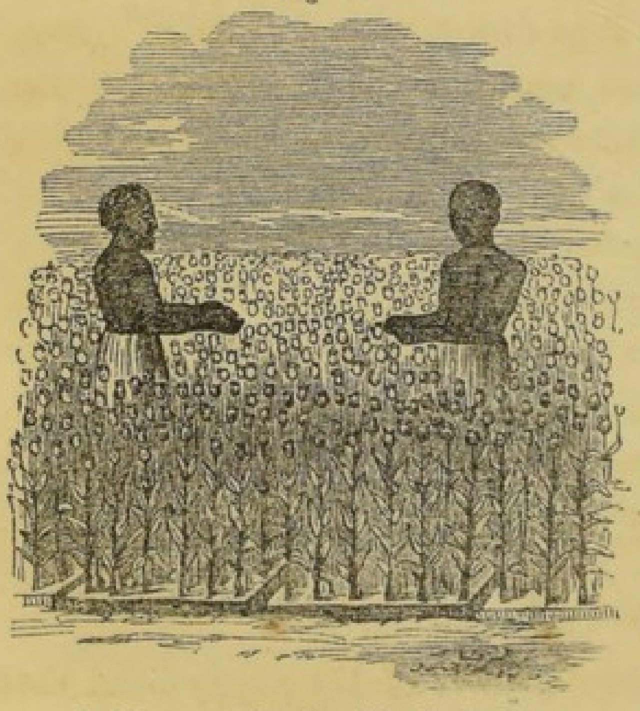
Fig. 65.



1. Poppy heads, showing the parallel incisions.
2. Nushturs, or poppy knives.

The appearance of the poppy fields in Bengal, and the way in which the dried juice is collected by the natives, is represented in fig. 66.

Fig. 66.



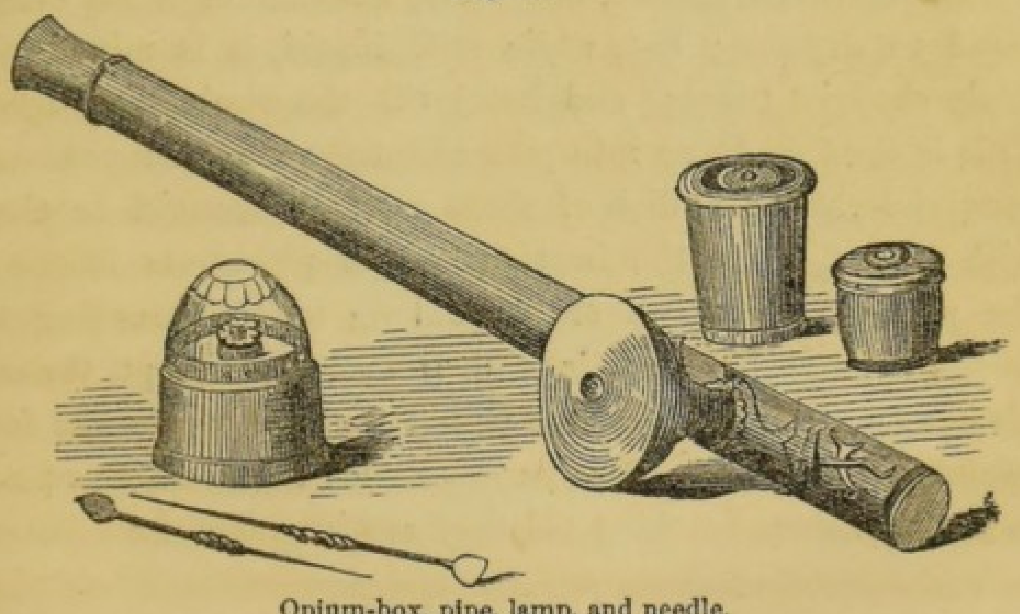
Indians scraping the dried juice from the poppy heads.

The best opium of commerce is a soft unctuous mass, of a reddish or blackish-brown colour, a waxy lustre, a strong, disagreeable odour, and a bitter, acrid, nauseous taste, which remains long in the mouth. It is chiefly collected in Asiatic Turkey, in Persia, and in India. The opium which comes from Smyrna is most esteemed in the European markets, while that which is produced in India is the most extensively used in Eastern countries. The greatest yield of good opium in

our Indian possessions is stated to be 41 lb. per imperial acre, and the average to be 20 to 25 lb.

2°. How it is used.—As a narcotic indulgence, opium is used in one or other of three ways. It is swallowed in the solid state in the form of pills; or in that of fluid tinctures, such as our common laudanum; or it is smoked in minute pipes, after the manner of tobacco. The first practice prevails in Mahomedan countries, especially in Turkey and Persia; the second among Christian nations, when individuals happen to become addicted to the practice; the third in China and the islands of the Indian Archipelago. In preparing it for smoking, the Chinese extract from the Indian opium all that water will dissolve. This is generally from one-half to three-fourths of the whole weight. They then evaporate the dissolved extract to dryness, and make it into little pills. One of these they put into a short tiny pipe, often made of silver, inhale a few puffs at a time, or one single long puff, and return the smoke through the nostrils and ears. This they repeat till the necessary dose has been taken (fig. 67).

Fig. 67.



Opium-box, pipe, lamp, and needle.

The needle is put through two holes on the opposite sides of the pipe, the pill is fixed on the middle of the needle, as seen in the figure, and immediately over the central hole of the pipe-bowl. The lamp is then applied, and the vapours sucked in.

At Singapore, the mode of using it is much the same as in China. "The opium shops," says Captain Wilkes, "are among the most extraordinary sights at Singapore. It is inconceivable with what avidity the smokers seek this noxious drug at the shop-windows. They then retire to the interior, where a number of sickly-looking persons, in the last stage of consumption, haggard and worn down with care, are seen smoking. The drug is sold in very small pieces, and for ten cents enough to fill a pipe once is obtained. With it are furnished a pipe, a lamp, and a couch to lie on, if such it may be called. The pipe is of a peculiar construction, and is in part of metal, having an interior or cup just large enough to contain a piece the size of a pea. The opium is difficult to ignite, and it requires much management in the smoker to obtain the necessary number of whiffs to produce intoxication in one habituated to its use. The couch is sometimes a rude bench, but more often a mat on the floor, with a small raised bench; and, in the frequented shops, is generally occupied by a pair of smokers, who have a lamp between them."*

In Borneo, Sumatra, and Java, the extract is not evaporated to dryness; but, while still liquid, it is mixed with finely-chopped tobacco and betel till the whole is absorbed. This is then made up into pills about the size of a pea. At convivial parties a dish of these peas is brought in along with a lamp, when the host takes the pipe, puts in one of the pellets, takes two or three long whiffs, returning the smoke through his nostrils, and, if he be an adept, through his eyes and ears. He then passes the pipe round the com pany, each of whom does the same with the same pipe; and so they continue smoking till they are intoxicated.†

* *United States Exploring Expedition*, vol. ii. p. 299.

† MARSDEN'S *History of Sumatra*, p. 238.

3°. Effects of Opium.—Used in any of the three ways I have mentioned, its sensible effects are nearly the same, varying, of course, with the quantity taken, with the constitution of the taker, and with the frequency of its previous use. The essential and primary action of the drug is upon the nervous system.

When taken in a moderate dose, the usual results of this action are, that the mind is exhilarated, the ideas flow more quickly, and a pleasurable or comfortable condition of the whole system is experienced, which it is difficult to describe. It thus acts in a similar way to our wines and spirituous liquors, and it is chiefly as a substitute for these that it is used in China.

It possesses, however, a wonderful power of sustaining the strength, which is not found in alcoholic drinks, and of enabling men to undergo fatigue and continued exertion under which they would otherwise inevitably sink. Thus the Halcarras, who carry litters and run messages through the provinces of India, when provided only with a small piece of opium, a bag of rice, and a pot to draw water from the wells, perform almost incredible journeys. The Tartar couriers also, who travel for many days and nights continuously, make much use of it. With a few dates or a lump of coarse bread, they traverse the trackless desert amidst privations and hardships which can only be supported under the influence of the drug—(Forbes). And hence travellers in the Ottoman dominions generally carry opium with them in the form of lozenges or cakes stamped with the Turkish legend, "Mash Allah," the gift of God—(Griffith). Even the horses in the East are sustained by its influence. The Cutchee horseman shares his store of opium with his flagging steed, which thus makes an incredible stretch, though apparently wearied out before—(Burnes).

The Turkish Theriakis, or opium-eaters, generally begin

with doses of from half a grain to two grains a-day, and gradually increase the quantity till it amounts to 120 grains, or sometimes more. The effect shows itself in one or two hours after it has been taken, and lasts for five or six. It produces a high degree of animation, which the Theriakis represent as the summit of happiness.

De Quincey took laudanum for the first time to dispel pain, and he thus describes the effect it had upon him :—"But I took it, and in an hour, oh, heavens! what a revulsion! what an upheaving, from its lowest depths, of the inner spirit! what an apocalypse of the world within me! That my pains had vanished was now a trifle in my eyes. This *negative* effect was swallowed up in the immensity of those positive effects which had opened before me—in the abyss of divine enjoyment thus suddenly revealed. Here was a panacea—a φαρμακον νηπενθες for all human woes. Here was the secret of happiness, about which philosophers had disputed for so many ages, at once discovered! Happiness might now be bought for a penny, and carried in the waistcoat pocket; portable ecstasies might be had corked up in a pint-bottle; and peace of mind could be sent down in gallons by the mail-coach."

Dr. Madden describes more soberly his sensations when under the influence of the drug in one of the coffee-houses at Constantinople. "I commenced with one grain. In the course of an hour and a half it produced no perceptible effect. The coffeehouse-keeper was very anxious to give me an additional pill of two grains, but I was contented with half a one; and in another half-hour, feeling nothing of the expected reverie, I took half a grain more, making in all two grains in the course of two hours. After two hours and a half from the first dose, my spirits became sensibly excited; the pleasure of the sensation seemed to depend on a universal expansion of mind and matter. My faculties appeared

enlarged; everything I looked at seemed increased in volume; I had no longer the same pleasure when I closed my eyes which I had when they were open; it appeared to me as if it was only external objects which were acted on by the imagination, and magnified into images of pleasure: in short, it was the 'faint exquisite music of a dream' in a waking moment. I made my way home as fast as possible, dreading at every step that I should commit some extravagance. In walking, I was hardly sensible of my feet touching the ground; it seemed as if I slid along the street impelled by some invisible agent, and that my blood was composed of some ethereal fluid, which rendered my body lighter than air. I got to bed the moment I reached home. The most extraordinary visions of delight filled my brain all night. In the morning I rose pale and dispirited; my head ached; my body was so debilitated that I was obliged to remain on the sofa all day, dearly paying for my first essay at opium-eating."*

These after-effects are the source of the misery of the opium-eater. The exciting influence of the drug is almost invariably followed by a corresponding depression. The susceptibility to external impressions and the muscular energy are both lessened. A desire for repose ensues, and a tendency to sleep. The mouth and throat also become dry; the thirst is increased; hunger diminishes; and the bowels usually become torpid.

When large doses are taken, all the above effects are hastened and heightened in proportion. The period of depression comes on sooner; the prostration of energy increases to actual stupor, with or without dreams; the pulse becomes feeble, the muscles exceedingly relaxed, and, if enough has been taken, death ensues.

Of course all these effects are modified by the constitu-

* MADDEN'S *Travels in Turkey*, vol. i. p. 25.

tion of the individual, by the length of time he has accustomed himself to take it, and by the circumstances in which he is placed. But upon all persons, and in all circumstances, its final effects, like those of ardent spirits taken in large and repeated doses, are equally melancholy and degrading. " A total attenuation of body," says Oppenheim, " a withered yellow countenance, a lame gait, a bending of the spine, frequently to such a degree as to assume a circular form, and glassy deep-sunken eyes, betray the opium-eater at the first glance. The digestive organs are in the highest degree disturbed; the sufferer eats scarcely anything, and has hardly one evacuation in a week. His mental and bodily powers are destroyed—he is impotent."

And then, " when the baneful habit has become confirmed, it is almost impossible to break it off. His torments, when deprived of the stimulant, are as dreadful as his bliss is complete when he has taken it. Night brings the torments of hell, day the bliss of paradise; and after long indulgence, he becomes subject to nervous pains, to which opium itself brings no relief. He seldom attains the age of forty, if he have begun the practice early."

Dr. Madden thus describes what he saw of its effects upon the confirmed Theriakis, as they are called, in the coffee-houses of Constantinople : " Their gestures were frightful ; those who were completely under the influence of the opium talked incoherently, their features were flushed, their eyes had an unnatural brilliancy, and the general expression of their countenances was horribly wild. The effect is usually produced in two hours, and lasts four or five ; the dose varies from three grains to a drachm. I saw one old man take four pills, of six grains each, in the course of two hours : I was told he had been using opium for five-and-twenty years. But this is a very rare example of an opium-eater passing thirty years of age, if he commences the prac-

tice early. The debility, both moral and physical, attendant on its excitement is terrible; the appetite is soon destroyed, every fibre in the body trembles, the nerves of the neck become affected, and the muscles get rigid: several of these I have seen in this place at various times, who had wry necks and contracted fingers; but still they cannot abandon the custom; they are miserable till the hour arrives for taking their daily dose; and when its delightful influence begins, they are all fire and animation. Some of them compose excellent verses, and others address the bystanders in the most eloquent discourses, imagining themselves to be emperors, and to have all the harems in the world at command."

The seductive influence of opium, and the almost irresistible and domineering power it acquires over the minds of its votaries, are not less wonderful than the mental happiness it confers during the exciting stage of its action on the body. Of this power of seduction even over the less delicate and susceptible organisation of our North European races, and of the absolute slavery to which it can reduce even the strongest minds among us, we have two remarkable examples in the celebrated Coleridge, and in the author of the *English Opium-Eater*. For many years Coleridge was a slave to opium, and the way in which he became addicted to it is thus described by himself, in a letter dated April, 1814:—"I was seduced into the accursed habit ignorantly. I had been almost bed-ridden for many months with swelling in my knees. In a medical journal I unhappily met with an account of a cure performed in a similar case, by rubbing in laudanum, at the same time taking a given dose internally. It acted like a charm—like a miracle. I recovered the use of my limbs, of my appetite, of my spirits; and this continued for near a fortnight. At length the unusual stimulus subsided, the complaint returned, the supposed remedy was recurred to—but I cannot go through the

dreary history. Sufficient to say, that effects were produced which acted on me by terror and cowardice of pain and sudden death"—and Coleridge became the slave of opium.

Subsequently, while living at the house of a friend in Bristol, he put himself in the hands of a medical man; and here the most melancholy part of his case exhibited itself. For, while he was pretending to be gradually lessening the dose under medical instructions, and while his friends were congratulating themselves that he was absolutely cured, by being brought down to twenty drops a-day, he was all the while buying laudanum secretly, and drinking it in large doses as before! How his moral sense must have been overborne, and by how powerful a fascination, before he could have stooped to a deception so degrading as this!

And how extreme his own misery and sense of impotence, when he could write of himself: "There is no hope. O God, how willingly would I place myself under Dr. Fox in his establishment; for my case is a species of madness, only that it is a derangement, an utter *impotence of the volition*, and not of the intellectual faculties. You bid me rouse myself. Go bid a man, paralytic in both arms, to rub them briskly together, and that will cure him. 'Alas!' he would reply, 'that I cannot move my arms is my complaint and my misery.'"

And even greater misery he paints in another letter written in the same year (1814). "Conceive a poor miserable wretch, who for many years has been attempting to beat off pain, by a constant recurrence to a vice that reproduces it. Conceive a spirit in hell employed in tracing out for others the road to that heaven from which his crimes exclude him! In short, conceive whatever is most wretched, helpless, and hopeless, and you will form as tolerable a notion of my state as it is possible for a good man to have."*

* COTTLE'S *Early Recollections*, vol. ii. p. 185.

Coleridge lived twenty years after the above was written, and conquered the evil habit. But after what struggles and tortures, mental and bodily, who can tell? De Quincey also, after seventeen years' use, and eight years' abuse, of the powers of opium, shook off his slavery. He has left us a graphic and impressive sketch of the terrible trials and temptations he had to withstand in finally abandoning the drug. "On the 24th of June, 1822," he says, "I began my experiment, having previously settled in my own mind that I would not flinch, but 'would stand up to the scratch' under any possible 'punishment.' About 170 or 180 drops had been my ordinary allowance for many months; occasionally I had run up as high as 300, and once nearly to 700: in repeated preludes to my final experiment, I had also gone as low as 100 drops, but had found it impossible to stand it beyond the fourth day, which, by the way, I have always found more difficult to get over than any of the preceding three. I went off under easy sail—130 drops a-day for three days; on the fourth I plunged at once to 80. The misery which I now suffered 'took the conceit out of me' at once; and for about a month I continued off and on about this mark: then I sunk to 60; and the next day to—none at all. This was the first day for nearly ten years that I had existed without opium. I persevered in my abstinence for ninety hours—*i. e.*, upwards of half a week. Then I took—ask me not how much. Say, ye severest, what would you have done? Then I abstained again; then took about 25 drops; then abstained—and so on."*

Under manifold pains, irritations, and distresses, some of which he has described, he manfully, and for months, persevered, and finally achieved his liberty. "I triumphed: but think not, reader, that therefore my sufferings were ended. Nor think of me as of one sitting in a *dejected*

* *Confessions of an English Opium-Eater*, Appendix.

state. Think of me as of one, even when four months had passed, still agitated, writhing, throbbing, palpitating, shattered; and much in the situation of him who has been racked, as I collect the torments of that state from the affecting account of them by William Lithgow, the most innocent sufferer of the times of James I. Meantime, I derived no benefit from any medicine, except one prescribed for me by an Edinburgh surgeon of great eminence—ammoniated tincture of valerian."

What a lesson does the experience of these two men read to us!

Similar effects are described as resulting from the smoking of opium in China. It appears to be very much a matter of indifference, therefore, whether the drug be taken in the solid form of pills, in the liquid form of laudanum, or in the more subtle form of heated vapour. The smoke acts more immediately than the other forms of the drug, but its final effects are very much the same.

4°. Extent to which Opium is used.—It is impossible to arrive at anything like an approximate idea of the quantity of opium consumed by the different nations of the world. Meyen asserts that the quantity consumed by the Malays of the Indian Archipelago, in Cochin-China and Siam, as well as in India and Persia, is so immense that, if we could obtain an exact statement of it, the amount would be quite incredible. In India we know that at least six and a-half millions of pounds of opium are annually bought by the East India Company from the native growers, and manufactured into a marketable condition. To produce this quantity will require upwards of 300,000 acres of land. It yields a revenue to the Company of three and a-half millions sterling, and is for the greatest part exported.

But besides this, the quantity consumed in India itself must be immense. The Rajpoots, and other Hindoo tribes,

present opium, at their visits and entertainments, with the same familiarity as the snuff-box is presented in Europe—(FORBES). And in some districts, as I have already mentioned, it is even administered to the horses. Within the Company's territories opium is given out with a permit to licensed dealers, so that the quantity there sold is pretty well known; but of the amount of the Indian consumption beyond their territories we can form no estimate.

As to China, we know that, in the season 1837–8, it imported from India three millions of pounds, and the importation has probably increased considerably since that time. To this importation must also be added the opium which China receives by land from the countries which border it towards the west. The consumption of China at the present moment is probably not less than four or five millions of pounds' weight, having a market value of as many pounds sterling. In the same year (1837–8) India exported about a million and a half of pounds to the islands of the Indian Archipelago and other places.

The consumption of the United Kingdom is of course trifling when compared with that of India or China; it is, however, greatly on the increase. Thus, the quantity imported into Great Britain was in

1839	41,000 pounds.
1852	114,000 "

Or it has increased nearly three times within fifteen years. This implies either the application of the drug to new purposes, or a greatly increased demand for the uses to which it was formerly applied.

Much uncertainty exists as to the extent to which the use of opium as a narcotic indulgence, in any of its forms, really prevails among our full-grown healthy adult population, either in town or country. According to De Quincey,

opium-eaters were already numerous among us thirty years ago. But those he mentions were either persons of talent and eminence, whom the gnawings of indigestion drove to opium as a stiller of pain, or poverty-stricken operatives in Manchester and other large towns, who of a Saturday evening soothed their cares and stayed their hunger with a grain or two of opium. And although the opinion is hazarded from time to time that the practice of opium-eating is extending among the body of the people, and individual cases occur now and then in which it is certain that the drug has been largely used,* yet statistical data are altogether wanting to support the idea that the consumption of opium as a narcotic indulgence is now, or is likely soon to become, a national vice among the inhabitants of any of the three kingdoms.

Another form of the opium evil, however, has been shown, upon unquestionable evidence, extensively to prevail. In the large manufacturing towns of Lancashire it is a common thing for mothers who work in the factories to put out their children to nurse, and it is equally common for the nurses to dose the children with opium for the purpose of keeping them quiet or of setting them to sleep. It was stated by the Rev. Mr. Clay, that in the town of Preston alone, in 1843, "upwards of sixteen hundred families were in the habit of using Godfrey's Cordial, or some other equally injurious compound," and that in one of the burial clubs in that town, sixty-four per cent. of the members die under five years of age."† The obvious conclusion was,

* A child died, for example, from the effects of opium in September, 1853, at Boxworth in Cambridgeshire, the mother because it was unwell, having placed a little piece of crude opium in its mouth to suck. To the announcement of this fact in the newspapers it was added, "that the mother and her family are all opium-eaters, and, though labouring people, spend 4s. a-week on the drug!" In my own frequent visits to the rural districts I have never heard of the use of opium as an indulgence in Scotland, and only in one country parish in the centre of England.

† *First Report of the Commissioners of Inquiry into the State of Large Towns*, 1844. Appendix, pp. 46, 48.

that the fatality among the children was connected with the use of the drug.

A writer in the *Morning Chronicle* of the 4th of January, 1850, thus describes the effects which this use of opium produces upon the health of the children: "The consequences of this system of drugging are suffusion of the brain, and an extensive train of mosenteric and glandular diseases. The child sinks into a low, torpid state, wastes away to a skeleton, except the stomach, producing what is known as pot-belly. One woman said, 'the sleeping stuff made them that they were always dozing, and never cared for food. They pined away. Their heads got big, and they died.'"

It cannot be denied, therefore, that in one melancholy form at least, the evil effects of opium are to be seen amongst us. And it is curious that this should be the very form of drugging from which the poppy is said to have derived its name. The diffusion of knowledge among the mothers of the factory districts is one of the most likely ways to remove this evil.

5°. Chemical constituents of Opium.—In regard to its chemical history, opium is probably the best known of all the vegetable extracts or inspissated juices used in medicine. It has been the subject of numerous and elaborate experimental and analytical investigations, and the results of these fill many interesting pages in our newest systems of organic chemistry.

How very complicated a substance even the purest opium is, the general reader will infer from the formidable list of peculiar principles which have been found in it. Besides familiar substances, such as gum, mucilage, resin, fat, caoutchouc, volatile oil, &c., it contains morphine, narcotine, codeine, narceine, thebaine, opianine, meconine, pseudomorphine, porphyroxine, papaverine, and meconic acid—eleven

peculiar organic compounds, which occur in greater or less quantity in nearly every sample of pure opium!

Of all these, the most active is that now almost universally known under the name of morphine or morphia. Of this invaluable medicine the best qualities of opium contain as much as ten per cent. It is colourless, void of smell, and nearly insoluble in water, but possesses an exceedingly bitter, unpleasant taste, and what are called by chemists alkaline properties. It is powerfully narcotic and poisonous, soothes nervous irritation, stills pain, and when taken in large doses, imparts a remarkable itchiness to the skin. It is described by some as producing upon the system all the effects of the natural opium. This, however, is not generally the case. Hence it has not, I believe, been anywhere attempted to substitute this pure chemical compound—the chemical composition of which is fixed, and the physiological effects constant and certain—for the crude and uncertain opium, in the production of pleasurable excitement and gratification.

The reason of this obviously is, that the full and peculiar effect of the natural drug is due to the combined and simultaneous action of all the numerous substances it contains. Each of these modifies the effect which would be produced by any one of the others taken singly—as the attraction of each planet modifies the course which would be taken by every one of the others, were it the only one which revolved round the sun. It is from the result of all these conjoined actions that the singular pleasure of the opium consumer is derived.

At least three of the constituents of opium which have been named above are known to be narcotic and poisonous. These are morphine, codeine, and thebaine. The codeine, in doses of five or six grains, produces in some a state of excitement resembling intoxication. The special action of the

other constituents upon the system is still unknown or undecided. Indeed, it is a remarkable thing in chemico-physiological history, that long as opium has been known, extensively as it has been used, both as a medicine and a luxurious indulgence, and numerous as are the opinions in regard to its mode of action which have been promulgated by medical authorities, we are still so unable to say what is the true action of this drug, that, in the words of Dr. Pereira, "we shall save ourselves much time and useless speculation by at once confessing our ignorance on this point." So far does physiology appear still to lag behind, where our chemistry is tolerably advanced.

It is, no doubt, the complicated nature of the problem which renders the physiological solution so difficult. In the crude opium, as I have said, nearly a dozen different substances are mixed up in different proportions and given at once. The effects of such a mixture we can scarcely hope, in all cases, satisfactorily to explain.

6°. Average composition of Opium.—The proportions in which the several active ingredients are mixed up in the opium of commerce varies much in different samples of the drug. The country, or locality, in which the plant is grown, the variety of poppy which is cultivated, the state of ripeness when the poppy-head is cut, the peculiarities of the season during which the sap is collected, the way in which it is dried and afterwards prepared for market—all these circumstances influence the proportions of its constituents, and consequently modify the action of the mixed substance upon the human system. The Smyrna opium is generally considered the best in the European market; but even in this the active ingredient, morphia, varies from four to fourteen per cent.

The mean of five analyses of Smyrna opium, made by

Mulder give for this variety the following average compo sition in a hundred parts :—

Morphine, ...	6.3
Narcotine, ...	7.7
Codeine, ...	0.7
Narceine, ...	9.0
Meconine, ...	0.6
Meconic acid, ...	6.1
Fat, ...	2.2
Caoutchouc, ...	4.5
Resin, ...	2.7
Gummy extractive, ...	25.3
Gum, ...	1.7
Mucilage, ...	18.7
Water and loss, ...	14.5
	100

Besides the substances above mentioned, five others, thebaine, opeanine, pseudo-morphine, porphyroxine, and papaverine, are found in opium in small proportions. All these have been discovered since the period of Mulder's analysis.

Of the above-named ingredients, morphia being the most active, is also the most valuable, and, by the proportion in which it exists in the samples from different localities, determines very much their relative estimation in the market. Hence the best Indian opium is inferior to the Turkish. It never yields more than five per cent. of morphia ; but it is richer in the less esteemed ingredient narcotine. The opium of Persia is equally poor in morphia.

These latter facts show that, though opium is chiefly collected and used in warm climates, yet that mere warmth of climate, whatever may be its other effects on the white poppy, does not alone cause the juice of its ripening capsules to be rich in morphia. On the contrary, British and German grown opium has been found to contain more morphia than that of commerce, and opium collected in France

has yielded as much as 16 to 28 per cent. of this ingredient.

This large yield of morphia possesses in this part of the world more of a scientific than of an economical interest, since both the dearness of labour and the variableness of climate in the British Islands are opposed to the idea of a profitable cultivation of opium. It may possibly be otherwise in some parts of France. Recent experiments made in that country are supposed to show that the variety of poppy already cultivated there for its seed may be so treated as to yield a harvest of opium at an expense which need not exceed one fourth the market value of the drug obtained. And as the seed which afterwards ripens uninjured, will pay all the ordinary cost of culture, it is believed by many that in the collection of opium there is the prospect of great future advantage to the agriculture of France.

In this plant, as in tobacco, variety as well as locality has an influence on the quantity of the active ingredients contained in its sap. Thus opium collected in Germany from the white poppy (variety *album*) yielded only 7 per cent. of morphia, while other samples collected from the black poppy (variety *nigrum*) yielded 16½ per cent.

It is a singular circumstance in the physiological history of morphia and its compounds, that, though so poisonous to man, it can be swallowed with comparative impunity, and in large doses, by apes, dogs, cats, hares, birds, and other animals. A full dose of morphia for a grown man is one-eighth of a grain; and of acetate or muriate of morphia, one-fourth of a grain; but an ape has been known to swallow 500 grains of morphia in a single month. It passes off harmlessly in the urine, which, in the case of the above ape, sometimes contained as much as one per cent. of morphia—(Flandin).

It is a curious physiological fact, that even in man the

active narcotic ingredients of opium often escape in a similar way. Morphia has been detected in the urine, and children have been poisoned by the milk of nurses who took much laudanum. This character the active constituents of opium possess in common with many other narcotic principles, such as those of the deadly nightshade, the henbane, the thorn-apple, the intoxicating fungus, and with many other substances used in medicine.

In India the opium is given out for sale with a permit to licensed dealers. But it is so much reduced in strength by admixtures of various kinds before it reaches the retailers in the bazaars, that it does not possess one-thirtieth of the intoxicating power of the natural drug—(Hooker).* In Java, where it is also a government monopoly, it is sold to Chinese dealers, who are bound to dilute it with tobacco and betel in a prescribed proportion, which varies with the quality of the opium, and to sell it thus reduced at a fixed price. Thus prepared for consumption, it is known by the name of *tandou*, and is extensively used. The opium-houses are only allowed to be open in the day time, that accidents from quarrelling may be as much as possible prevented.

7°. Influence of race and constitution.—This precaution is the more necessary in Java, because of the peculiarly exciting influence which opium exercises over the Javanese, the Malays, and the negro races.

Although both Coleridge and De Quincey have given such glowing descriptions of the action of opium in their individual cases, yet the British opium-eater in general is by no means subject to the extraordinary excitement either of body or of mind which these writers describe. The common effect, according to Dr. Christison, "is merely to re-

* *Himalayan Journals*, vol. i. p. 86.

move torpor and sluggishness, and to make the opium-consumer, in the eyes of his friends, an active and conversable man."*

But, as we have seen, the general effects of the drug in Turkey and Persia, as related by travellers, are very different. And they are still more exciting in the Indian Archipelago, and among some of the African races.

"The Javanese," says Lord Macartney, "under an extraordinary dose of opium, become frantic as well as desperate. They acquire an artificial courage; and, when suffering from misfortune and disappointment, they not only stab the objects of their hate, but sally forth to attack in like manner every person they meet, till self-preservation renders it necessary to destroy them." They shout, as they run, *Amok, amok;* which means, "kill, kill;" and hence the phrase, *running a-muck.* Captain Beekman was told of a Javanese who ran a-muck in the streets of Batavia, and had killed several people, when he was met by a soldier, who ran him through with his pike. But such was the desperation of the infuriated man, that he pressed himself forward on the pike, until he got near enough to stab his adversary with a dagger, when both expired together.

On the Malays the effects of opium are described as being nearly the same both in kind and in degree. In reading of them, one is reminded of the excitement which formerly prevailed in a less fatal form at Donnybrook and other Irish fairs, when an unusual dose of poteen had been administered to the *boys.*

The influence of race, as it affects the physiological action either of substances introduced into the stomach, or of ideas presented to the mind, is the same in kind as the influence of individual constitution. It is only greater in de-

* *Treatise on Poisons*, p. 721.

gree, and startles us sometimes because of the extent to which it appears exaggerated. The influence of constitution is recognised and considered in every dose of medicine we take or administer, and in the way in which good or evil tidings are communicated to our friends. We more rarely allow for differences of race in dealing with foreign nations, or in criticising their behaviour and actions under given circumstances.

In the Malays and Javanese we have the excitable temperament, accompanied by the unrestrained outward forms of expression, which are characteristic of Eastern nations. What affects us Anglo-Saxons lightly or slowly, touches them instantly, and penetrates deep. The emotions which, when awakened, we are accustomed to restrain and hide, they openly and vividly display, and by indulgence heighten often to an overpowering degree. The Negro tribes partake of a similar organisation. "In this respect," says Mrs. Beecher Stowe, "they have an Oriental character, and betray their tropical origin. Like the Hebrews of old, and the Oriental nations of the present day, they give vent to their emotions with the utmost vivacity of expression, and their whole bodily system sympathises with the movements of their minds. When in distress, they actually lift up their voices to weep, and 'cry with an exceeding bitter cry.' When alarmed, they are often paralysed, and rendered entirely helpless." This susceptibility affects all their relations both to living and dead things. Opium operates upon different individuals among them in different ways, as it does upon the different individuals of European races; but upon all of them it produces those more marked and striking effects which, among ourselves, we only see in rare instances, and in persons of uncommonly nervous temperament.

A singular illustration of the effect of mixed substances upon the human constitution, when in a state of disease, is

presented in the use of a mixture of opium with corrosive sublimate by the confirmed opium-eaters of the East. The drug, in its usual form, gradually loses its effect upon the habitual consumer, so that the dose must be increased from time to time, if the influence of the drug is to be maintained. But at length, even this resource fails the inveterate opium-eaters of Constantinople, and no increase of dose will procure for them the desired enjoyment, or even relieve them from bodily pain. In this emergency, they have recourse to the pernicious corrosive sublimate. Mixing at first a minute quantity of this substance with their daily dose of opium, they increase it by degrees, till they reach the limit of ten grains a-day, beyond which it is usually unsafe to pass. This mixture acts upon their long-tortured frames, when neither of the ingredients, taken alone, will either soothe or exhilarate. But the use of the new medicine only protracts a little longer the artificial enjoyment, which has become a necessary of life, finally bringing to a more miserable termination the career of the debilitated and distorted Theriaki.

8°. Opium compared with wine.—I have said that in moderate doses opium acts in a similar way to our wines and spirituous liquors, and that it is as a substitute for these that the Chinese use it. By this I do not mean that its physiological effects are precisely the same, although the main purpose for which both are used by many—that of care-dispellers—may be the same. On the contrary, there are many points of difference in the effects which alcoholic drinks and opium respectively produce.

The English Opium-eater thus enumerates some of the points by which, according to his experience, their several actions are distinguished : "Wine robs a man of his self-possession ; opium greatly invigorates it. Wine unsettles and clouds the judgment, and gives a preternatural bright-

ness and a vivid exaltation to the contempts and the admirations, the loves and the hatreds, of the drinker; opium, on the contrary, communicates serenity and equipoise to all the faculties, active or passive; and with respect to the temper and moral feelings in general, it gives simply that sort of vital warmth which is approved by the judgment, and which would probably always accompany a bodily constitution of primeval or antediluvian health. . . . To sum up all in one word, a man who is inebriated, or tending to inebriation, is, and feels that he is, in a condition which calls up into supremacy the merely human—too often the brutal—part of his nature; but the opium-eater (I speak of him who is not suffering from any disease, or other remote effects of opium) feels that the diviner part of his nature is paramount; that is, the moral affections are in a state of cloudless serenity; and over all is the great light of the majestic intellect."

This language of the Opium-Eater must be read with that amount of allowance which we naturally concede to poetical writers, who aim at effect in the language they select, and are not afraid of the startling and uncommon.

9°. Is Opium necessarily deleterious?—We have been in the habit, in this country, of regarding the use of opium in the way of indulgence as an unmitigated evil. And although to accede to the highly-coloured eulogium of Mr. De Quincey would be to rush to the opposite extreme, yet it may perhaps be conceded that our attention has been generally too much directed to the most dismal features of the practice, and that we may have judged too hastily as to its more general effects. Thus Dr. Burnes, long resident in Cutch and at the court of Scinde, says, that "in general the natives do not suffer much from the use of opium;" and that it "does not seem to destroy the powers of the body, nor to enervate the mind, to the degree that might be

imagined." And as to the Chinese, Dr. Macpherson observes, that "although the habit of smoking opium is universal among rich and poor, yet they are a powerful, muscular, and athletic people, and the lower orders more intelligent, and far superior in mental acquirements, to those of corresponding rank in our own country."

Among those also who have seen much of the use of opium in Eastern countries, there are some who, so far from pronouncing the practice to be an unmitigated evil, actually prefer its general use to that of alcoholic drinks. Thus Dr. Eatwell, of the East India Company's Service, whose knowledge of the history and action of opium is acknowledged to be most extensive, writes as follows:—

"The question to be determined is not what are the effects of opium used in excess, but what are its effects on the moral and physical constitution of the mass of individuals who use it habitually, and in *moderation*, either as a stimulant to sustain the frame under fatigue, or as a restorative and sedative after labour, bodily or mental? Having passed three years in China, I can affirm thus far, that the effects of the abuse of the drug do not come very frequently under observation, and that when cases do occur, the habit is frequently found to have been induced by the presence of some painful chronic disease, to escape from the sufferings of which the patient has fled to this resource. That this is not always the case, however, I am perfectly ready to admit; and there are doubtless many who indulge in the habit to a pernicious extent, led by the same morbid influences which induce men to become drunkards in even the most civilised countries; but these cases do not, at all events, come before the public eye. As regards the effects of the habitual use of the drug on the *mass* of the people, I must affirm, that no injurious results are visible. The people generally are a muscular and well-formed race, the labouring portion being

capable of great and prolonged exertion under a fierce sun in an unhealthy climate. Their disposition is cheerful and peaceable, and quarrels and brawls are rarely heard even amongst the lower orders; whilst in general intelligence they rank deservedly high amongst orientals.

"I conclude, therefore, with observing, that the proofs are still wanting to show that the moderate use of opium produces more pernicious effects upon the constitution than the moderate use of spirituous liquors; whilst at the same time it is certain that the consequences of the abuse of the former are less appalling in their effects upon the victim, and less disastrous to society at large, than the consequences of the abuse of the latter."*

That the effects of opium-eating and opium-smoking in China are not so melancholy as we have been accustomed to suppose, and that, on the whole, they are not worse than those which are produced among ourselves by fermented liquors,—this is the substance of Dr. Eatwell's testimony; and so far it is both interesting and satisfactory. But his language is not laudatory like that of De Quincey. He palliates the vicious indulgence, but says nothing which should recommend the practice to his readers. The medical missionaries to China inform us that confirmed opium-consumers use daily from thirty to two hundred grains of the pure extract, which is equal to twice as much as the crude opium.† But were such cases very numerous, they ought to come more frequently under the public eye than, from the testimony of Dr. Eatwell, appears to be the case.

10°. PRACTICAL CONCLUSIONS.—The true state of the question in its practical bearings upon ourselves may be summed up as follows:—

First, It is certain that opium, like spirituous liquors,

* *Pharmaceutical Journal*, vol. xi. p. 364.

† Ten grains cost 22 cash, about one penny.

produces most melancholy body-and-soul-destroying effects upon those who give themselves up to its use as a narcotic indulgence. If day brings them the bliss of heaven, night brings with it the torments of hell.

Second, It is certain, also, that some can continue for years to use it in small doses as a narcotic indulgence, without becoming slaves to it, or without appearing to be sensibly affected by it in their general health.

Third, But that it is of all indulgences the most wonderfully seductive, and is therefore a most dangerous substance to become familiar with. The infatuation sometimes reaches such a point that the certainty of death, and of all the fearful infirmities which in this case precede death, have no influence on the victim. He coldly answers those who warn him of his danger that the opium-happiness is beyond compare—(Pouqueville).

Fourth, That to give up the indulgence produces tortures of mind and body which make cowards and recreants of the most resolute. To this fact, the testimony of Coleridge and De Quincey has been already quoted.

Am I then—is the practical question each of my readers will put to himself—am *I* possessed of moral and physical courage, such as will enable *me* to resist the fascinations of this insidious drug, to give it to, or to withhold it from, *myself*, as may be most for my good? Do those around me, and who may be influenced by my example, possess equal self-control? The wisest, I believe, will hesitate to answer these questions in the affirmative, and, for themselves and those they love, will most anxiously shun the great risk.

VI. Substitutes for Opium.—Substitutes for opium have been sought for and used in different countries.

1°. *Bull-hoof.*—In Jamaica, the *Muracuja ocellata*, or bull-hoof, has been called Dutchman's laudanum, because

certain parts of the plant are supposed to possess the same virtues as the poppy. The flowers are principally employed, and when infused or mixed in the state of powder with wine or spirits, they are regarded as a safe and effectual narcotic--(BROWN).

2°. *The Lettuce.*—In Europe, the different species of the lettuce (*Lactuca*) are capable, to a certain extent, of supplying the place of the poppy. The juice of these plants, when collected and dried, has considerable resemblance to opium.

If the stem of the common lettuce, when it is coming into flower, be wounded with a knife, a milky juice exudes. In the open air this juice gradually assumes a brown colour, and dries into a friable mass. The smell of this dried juice is strongly narcotic, recalling that of opium. It has a slightly pungent taste, but, like opium, leaves a permanent bitter in the mouth. It acts upon the brain after the manner of opium, and induces sleep.

To this crude extract the name of *Lactucarium* has been given. Like opium, it dissolves in water to the extent of about one-half, and in this soluble portion the narcotic virtue resides. The principal active ingredient is supposed to be a peculiar substance named *lactucin*, of which the crude extract contains about one-fourth of its weight. It contains other active ingredients, however—the chemical nature and physiological influence of which have not as yet been rigorously investigated.

The lactucarium is one of those narcotics in which many of us unconsciously indulge. The eater of green lettuce as a sallad takes a portion of it in the juice of the leaves he swallows; and many of my readers, after this is pointed out to them, will discover that their heads are not unaffected after indulging copiously in a lettuce salad. Eaten at night, the lettuce causes sleep; eaten during the day, it soothes

and calms, and allays the tendency to nervous irritability. And yet the lover of lettuce would probably take it very much amiss if he were told that he ate his green leaves, partly at least, for the same reason as the Turk or Chinaman takes his whiff from the tiny opium-pipe—that, in short, he was little better than an opium-eater, and his purveyor than the opium-smugglers on the coast of China.

3°. *Syrian Rue.*—The seeds of the *Peganum harmala*, the Syrian or Steppe rue, are used by the Turks as a spice, and as a red dye. But they are also eaten as a narcotic indulgence, in the place of opium and hemp. I do not know to what extent this practice now prevails ; but, according to Belonius, the Turkish emperor Solyman kept himself intoxicated by the use of the seeds of Syrian rue.

The active virtues of this seed appear to reside in its husk. From this husk Fritsche has recently extracted two interesting peculiar principles, to which he has given the names of Harmin and Harmalin. The chemical properties of these substances have been studied to some extent, but their physiological action on the system has not been investigated. We are therefore still in the dark as to the immediate cause of the intoxicating effects of these seeds.

CHAPTER XVIII.

THE NARCOTICS WE INDULGE IN.

INDIAN HEMP.

The common European the same as the Indian hemp.—Its narcotic resin more abundant in warm climates.—Mode of collecting the resin.—The Churrus or Kirs, Gunjah, Bang, and alcoholic extract.—Forms in which the hemp is used.—The Haschisch of Turkey.—Antiquity and extent of its use.—The nepenthes of Homer an Egyptian drug.—The tombeki of India.—Origin of the word "assassin."—Use of hemp in Africa and America.—Effects of hemp on the system.—Sometimes produces catelepsy.—Experience of M. Moreau.—Excitability produced by it.—Errors of perception.—Its effects vary with the individual and with the race.—Influence on Orientals greater, on Europeans less.—Experience of M. de Saulcy.—Chemistry of the hemp plant.—Its volatile oil.—The natural resin and resinous extract probably contain several substances.—Hemp compared with opium.—Differences in their comparative effects.—Extent to which hemp is used.

VII. Indian Hemp.—Little is popularly and practically know in northern Europe of the use of hemp as a narcotic indulgence; yet in the East it is as familiar to the sensual voluptuary as the opium treated of in the preceding chapter.

Our common European hemp (*Cannabis sativa*), fig. 68, so extensively cultivated for its fibre, is the same plant with the Indian hemp (*Cannabis Indica*), which from the remotest times has been celebrated among Eastern nations for its narcotic virtues. The plant came to Europe from Persia,

and is supposed by many to be a native of India; but, like tobacco and the potato, it has a wonderful power of adapting itself to differences in soil and climate. Hence it is now cultivated, not merely on the plains of Persia, India, and Arabia, but in Africa, from its northern to its southern extremities; in America, all over its north-eastern states and provinces, and on the flats of Brazil; and in Europe, in almost every kingdom and country. In northern Russia it is an important article of culture, even as far north as Archangel, and from that region our manufacturers have been accustomed to receive large supplies of its valuable fibre.

Fig. 68.

Cannabis sativa—The cultivated hemp.
Scale, half inch to a foot.

In the sap of this plant—probably in all countries—there exists a peculiar resinous substance, in which the esteemed narcotic virtue resides. In northern climates, the proportion of this resin in the several parts of the plant is so small as to have escaped general observation. The whole plant, indeed, has a peculiar smell, even when grown in Europe, which, though not unpleasant to every one, often gives headache and giddiness to persons who remain long in a hemp field. This probably arises from an escape into the air of a small quantity of a volatile narcotic principle.

But in the warmer regions of the East, the resinous sub-

stance is so abundant as to exude naturally, and in sensible quantity, from the flowers, from the leaves, and from the young twigs of the hemp-plant. We have already seen that climate modifies considerably the proportions of the active ingredients contained in the dried leaf of tobacco, and in the dried juice of the poppy. The hemp-plant exhibits a still more striking illustration of the influence of climate upon the chemical changes which take place in the interior of living vegetables. It grows well, and produces abundance of excellent fibre in the north, but no sensible proportion of narcotic resin. It grows still better, and more magnificently, in tropical regions; but there its fibre is worthless and unheeded, while for the resin it spontaneously yields it is prized and cultivated.

1°. MODE OF COLLECTING THE RESIN AND PLANT.—In India the resinous exudation of the hemp-plant is collected in various ways. In Nepaul it is gathered by the hand in the same way as opium. This variety is very pure, and much prized. It is called *momeea*, or waxen *churrus*. It remains soft, even after continued drying; has a fragrant narcotic odour, which becomes strong and aromatic on heating. Its taste is slightly hot, bitterish, and acrid, yet balsamic. In Central India, men covered with leather aprons run backwards and forwards through the hemp-fields, beating the plants violently. By this means the resin is detached and adheres to the leather. This is scraped off, and is the ordinary churrus of Cabul. It does not bring so high a price as the momeea. In other places the leather aprons are dispensed with, and the resin is collected on the naked skins of the coolies. In Persia it is collected by pressing the resinous plant on coarse cloths, and afterwards scraping the resin from these, and melting it in a little warm water. The churrus, or "kirs," of Herat is considered one of the best and most powerful varieties of the drug.

The plant itself is often collected and dried for the sake of the resin it contains. The whole plant gathered when in flower, and dried without the removal of the resin, is called *gunjah*. In this form it is sold in the markets of Calcutta in bundles about three inches in diameter, and containing each twenty-four plants. The larger leaves and seed capsules separated from the stalks are called *bang*, *subjee*, or *sidhee*. This form is less esteemed than the gunjah.* The tops or tender parts of the plant, the flowers, and even the pistils of the flowers, are separated, and when dried alone are very powerful, and much esteemed. The seeds, I believe, are never used as a narcotic indulgence. In some medical works they are spoken of as cramp-stilling and pain-removing; but if they really possess these virtues, it must be in a very inferior degree; and they probably reside in the husk,† and not in the body of the seed itself.

When boiled in alcohol the gunjah yields as much as one-fifth of its weight of resinous extract, and hence this method of preparing the drug in a pure state has been recommended as the most efficient and economical. I am not aware, however, that it is anywhere adopted in the East.

2°. Forms in which hemp is used.—Among the ancient Saracens and the modern Arabs, in some parts of Turkey, and generally throughout Syria, the preparations of hemp in common use were, and are still, known by the names of *haschisch*, *hashash*, or *husheesh*. The most common form of haschisch, and that which is the basis of all others, is prepared by boiling the leaves and flowers of the hemp with water, to which a certain quantity of fresh butter has been added, evaporating the decoction to the thickness of a syrup, and then straining it through cloth. The

* *Pharmaceutical Journal*, vol. i. p. 490.

† As is the case with the Syrian rue, *Peganum harmala*, described at the close of the preceding chapter.

butter thus becomes charged with the active resinous principle of the plant, and acquires a greenish colour. This preparation retains its properties for many years, only becoming a little rancid. Its taste, however, is very disagreeable, and hence it is seldom taken alone, but is mixed with confections and aromatics—camphor, cloves, nutmegs, mace, and not unfrequently ambergris and musk—so as to form a sort of electuary. The confection used among the Moors is called *el mogen*, and is sold at an enormous price. *Dawamese* is the name given by the Arabs to that which they most commonly use. This is frequently mingled, however, with other substances of reputed aphrodisiac virtues, to enable it to administer more effectually to the sensual gratifications, which are the grand object of life among many of the orientals.

The Turks give the names of *hadschy malach* and *madjoun* to the compositions they use for purposes of excitement. According to Dr. Madden, the madjoun of Constantinople is composed of the pistils of the flowers of the hemp-plant ground to powder, and mixed in honey with powdered cloves, nutmegs, and saffron.

Thus the Indian hemp and its products are used in one or other of four different forms :—

First, The whole plant dried and known by the name of gunjah ; or the larger leaves and capsules dried and known as bang, subjee, or sidhee ; or the tops and tender parts of the plants collected after they have been in flower, and which in some places are called haschisch ; or the dried flowers, called in Morocco *kief*, a pipe of which, scarcely the size of an English pipe, is sufficient to intoxicate ; or the dried pistils of the flower as they enter into the composition of the madjoun of the Turks. These several parts of the dried plant, when newly gathered, have a rapid and energetic action. Their efficacy diminishes, however, by keeping.

Second, The resin which naturally exudes from the leaves and flowers, and is, when collected by the hand, called momeea; or the same beaten off with sticks, and sold by the name of churrus.

Third, The extract obtained by the use of butter, which, when mixed with spices, forms the dawamese of the Arabs, and is the foundation of the haschisch of many Eastern countries and districts.

Fourth, The extract obtained by means of alcohol from the gunjah. This is said to be very active, but I am not aware of its being in use in the East.

The dried plant is smoked and sometimes chewed. Five or ten grains reduced to powder are smoked from a common pipe alone with ordinary tobacco, or from a water pipe (*narghilé*), with a variety of tobacco called tombeki.* The resin and resinous extract are generally swallowed in the form of pills or boluses.

3°. ANTIQUITY AND EXTENT OF ITS USE.—In one or other of the forms above mentioned the hemp-plant appears to have been used from very remote times. The ancient Scythians are said by Herodotus to have excited themselves by "inhaling its vapour." Homer makes Helen administer to Telemachus, in the house of Menelaus, a potion prepared from the nepenthes, which made him forget his sorrows. This plant had been given to her by a woman of Egyptian Thebes; and Diodorus Siculus states that the Egyptians laid much stress on this circumstance, arguing that Homer must have lived among them, since the women of Thebes were actually noted for possessing a secret by which they could dissipate anger or melancholy. This secret is supposed to

* The tombeki is said to be the leaf of a species of Lobelia. It is smoked in a narghilé, and is exceedingly narcotic; so much so that it is usually steeped in water for a few hours, to weaken it before it is used, and the pipe is charged with it while it is still wet.

have been a knowledge of the qualities of hemp. Under the name of *beng* it is also mentioned in the *Arabian Nights*, translated by Lane, as the narcotic used by Haroun al Raschid and other heroes of the tales.

It is curious how common and familiar words sometimes connect themselves with things and customs of which we know absolutely nothing. The word *assassin*—a foreign importation now long naturalized among us—is of this kind. M. Sylvester de Sacy, the well-known orientalist, says that this word was derived from the Arabic name of hemp. It was originally used in Syria to designate the followers of "the old man of the mountain," who were called *Haschischins*, because among them the haschisch was in frequent use, especially during the performance of certain of their mysterious rites. Others say that, during the wars of the Crusaders, certain of the Saracen army, intoxicated with the drug, were in the habit of rushing into the camps of the Christians and committing great havoc, being themselves totally regardless of death; that these men were known by the name of hashasheens, and that thence came our word "assassin." The oriental term was probably in use long before the time of the Crusades, though the English form and use of the word may have been introduced into Europe at that period.

Nor is the use of hemp less extended than it is ancient. In the plains of India it is consumed in every form, and on the slopes of the Himalayas, it is cultivated for smoking, as high up as the valleys of Sikkim. In Persia, in the east of Europe, and in Mahommedan countries, it is in extensive use. In Northern Africa it is largely employed by the Moors. In central and tropical Africa it is almost everywhere known as a powerful medicine and a desired indulgence. In Southern Africa the Hottentots use it under the name of *dacha*, for purposes of intoxication; and when the

Bushmen were in London, they smoked the dried plant in short pipes made of the tusks or teeth of animals. And what is more astonishing, when we consider the broad seas which intervene, even the native Indians of Brazil know its value, and delight in its use; so that over the hotter parts of the globe generally, wherever the plant produces in abundance its peculiar narcotic principle, its virtues may be said to be known, and more or less extensively made use of.*

4°. EFFECTS OF HEMP ON THE SYSTEM.—This wide use of the plant implies that the effects of hemp upon the system are generally very agreeable. In India it is spoken of as the increaser of pleasure, the exciter of desire, the cementer of friendship, the laughter-mover, and the causer of the reeling gait,—all epithets indioative of its peculiar effects. Linnæus describes its power as "narcotica, phantastica, dementens, anodyna et repellens;" while in the words of Endlicher, "Emollitum exhilarat animum, impotentibus desideriis tristem, stultam lætitiam provocat, et jucundissima somniorum conciliat phantasmata."

a. The effects of the *churrus* or natural resin have been carefully studied in India by Dr. O'Shaughnessy. He states that when taken in moderation it produces increase of appetite and great mental cheerfulness, while in excess it causes a peculiar kind of delirium and catalepsy. This last effect is very remarkable, and we quote his description of the results of one of his experiments with what is considered a large dose for an Indian patient:—

"At two P.M. a grain of the resin of hemp was given to a rheumatic patient; at four P.M. he was very talkative, sang, called loudly for an extra supply of food, and declared himself in perfect health. At six P.M. he was asleep. At eight P.M. he was found insensible, but breathing with perfect regularity. His pulse and skin were natural, and the

pupils freely contracted on the approach of light. Happening by chance to lift up the patient's arm, the professional reader will judge of my astonishment when I found it remained in the posture in which I placed it. It required but a very brief examination of the limbs to find that by the influence of this narcotic the patient had been thrown into the strangest and most extraordinary of all nervous conditions, which so few have seen, and the existence of which so many still discredit—the genuine catalepsy of the nosologist. We raised him to a sitting posture, and placed his arms and limbs in every imaginable attitude. A waxen figure could not be more pliant or more stationary in each position, no matter how contrary to the natural influence of gravity on the part! To all impressions he was meanwhile almost insensible."

This extraordinary influence he subsequently found to be exercised by the hemp extract upon other animals as well as upon man. After a time it passes off entirely, leaving the patient altogether uninjured.

In this effect of the hemp in India we see a counterpart of many of the wonderful feats performed by the fakeers and other religious devotees of that country. It indicates probably the true means also by which they are enabled to produce them.

How much power a little knowledge gives to the dishonest and designing of every country, over the ignorant and unsuspecting masses!

b. Again, the effects of the *haschisch* of the Arabians, which probably differ little from those of hemp taken in any of its forms, have been described to us from his own personal experience by a French physician, M. Moreau. When taken in small doses, its effect, he says, is simply to produce a moderate exhilaration of spirits, or at most a tendency to unseasonable laughter. Taken in doses sufficient to induce

the *fantasia*, as its more remarkable effects are called in the Levant, its first influence is the same as when taken in a small dose; but this is followed by an intense feeling of happiness, which attends all the operations of the mind. The sun shines upon every thought that passes through the brain, and every movement of the body is a source of enjoyment. M. Moreau made many experiments with it upon his own person—appears indeed to have fallen into the habit of using it even after his return to France—and he describes and reasons upon its effects as follows :—

"It is really *happiness* which is produced by the haschisch; and by this I mean an enjoyment entirely moral, and by no means sensual, as might be supposed. This is a very curious circumstance, and some remarkable inferences might be drawn from it. . . . . . For the haschisch-eater is happy, not like the gourmand, or the famishing man when satisfying his appetite, or the voluptuary in the gratification of his amative desires—but like him who hears tidings which fill him with joy, or like the miser counting his treasures, the gambler who is successful at play, or the ambitious man who is intoxicated with success."

This glowing description of the effects of the haschisch, though given by one who had often used it, is on that very account, like the pictures of the opium-eater, open to suspicion. We feel as if it were intended as a kind of excuse or justification of the indulgence on the part of the writer.

When first it begins to act, the peculiar effects of the haschisch may be considerably diminished, or altogether checked, by a firm exertion of the will, "just as we master the passion of anger by a strong voluntary effort." By degrees, however, the power of controlling at will and directing the thoughts diminishes, till finally all power of fixing the attention is lost, and the mind becomes the sport of

every idea which either arises within itself, or is forced upon it from without.

"We become the sport of impressions of every kind. The course of our ideas may be broken by the slightest cause. We are turned, so to speak, by every wind. By a word or a gesture, our thoughts may be successively directed to a multitude of different subjects with a rapidity and lucidity which are truly marvellous. The mind becomes possessed with a feeling of pride, corresponding to the exaltation of its faculties, which it is conscious have increased in energy and power. The slightest impulse carries it along. Hence those who make use of the haschisch in the East, when they wish to give themselves up to the intoxication of the *fantasia*, withdraw themselves carefully from everything which could give to their delirium a tendency to melancholy, or excite anything but feelings of pleasurable enjoyment. They profit by all the means which the dissolute manners of the East place at their disposal. It is in the midst of the harem, surrounded by their women, under the charm of music and of lascivious dances performed by the almees, that they enjoy the intoxicating *dawamese;* and, with the aid of superstition, they find themselves almost transported to the scene of the numberless marvels which the Prophet has collected in his paradise."

The errors of perception, in regard to time and place, to which the patient is liable during the period of fantasia, are remarkable. Minutes seem hours, and hours are prolonged into years, till at last all idea of time seems obliterated, and the past and the present are confounded together. Every notion, in this curious condition, seems to partake of a certain degree of exaggeration. One evening M. Moreau was traversing the passage of the opera when under the influence of a moderate dose of haschisch. He had made but a few steps when it seemed to him as if he had been there for two

or three hours; and as he advanced, the passage seemed interminable, its extremity receding as he pressed forward.

The effect produced by hemp in its different forms varies, like that of opium, both in kind and in degree, with the race of men who use it, and with the individual to whom it is administered. Upon orientals, its general effect is of an agreeable and cheerful character, exciting them to laugh, dance, and sing, and to commit various extravagances—acting as an aphrodisiac, and increasing the appetite for food. Some, however, it renders excitable and quarrelsome, and disposes to acts of violence. It is from the extravagant behaviour of individuals of this latter temperament that the use and meaning of our word assassin have most probably arisen. It is from such effects of this substance also that we obtain a solution of the extravagances and barbarous cruelties which we read of as practised occasionally by Eastern despots.

Yet, even among orientals, according to Dr. Moreau, there are some on whom the drug produces no effect whatever—upon whom, at least, doses are powerless which are usually followed by well-marked phenomena. As is the case with opium, long use also makes larger doses necessary. To some even a drachm of the churrus becomes a moderate dose, though sufficient to operate upon twenty ordinary men.

Upon Europeans generally, at least in Europe, its effects have been found to be considerably less in degree than upon orientals. In India Dr. O'Shaughnessy had seen marked effects from half a grain of the extract, or even less, and had been accustomed to consider one grain and a half a large dose; in England he had given ten or twelve or more grains, to produce the desired effect."* In kind, also, its effects upon Europeans differ somewhat from those produced upon Asiatics. It has never been known, for example, to produce

* PERERIA, *Materia Medica*, p. 1242.

that remarkable cataleptic state, described in a previous page as having been observed in India even from a comparatively small dose of the hemp extract; nor, so far as I am aware, has it ever obtained a footing in any part of Europe as a narcotic indulgence.

It requires, indeed, a long and gradual training to its use before its boasted effects can be fully experienced, and this fortunately is not attempted yet in Europe. While in Jerusalem, M. de Saulcy, with the view of passing pleasantly a tedious evening, indulged himself in a dose of haschisch, which, upon his uninitiated constitution, produced only unpleasant results. He thus speaks of it—

"The experiment to which we had recourse for passing our time, turned out so utterly disagreeable, that I may safely say not one of us will ever be tempted to try it again. The *haschisch* is an abominable poison, which the dregs of the population alone drink and smoke in the East, and which we were silly enough to take in too large a dose on the eve of new-year's day. We fancied we were going to have an evening of enjoyment, but we nearly died through our imprudence. As I had taken a larger dose of this pernicious drug than my companions, I remained almost insensible for more than twenty-four hours; after which I found myself completely broken down, with nervous spasms, and incoherent dreams, which seemed to have endured a hundred years at least."*

5°. Chemical constituents of the Indian Hemp.—Of the chemistry of the Indian hemp comparatively little is yet known. Had it been as long familiar to Europeans, or used as extensively by them, as it is in the East, it would probably, like opium, have already been the subject of repeated chemical investigations. The volatile oil and the

* *Journey round the Dead Sea.* By F. de Saulcy. Vol. i. p. 140.

resin of hemp are the only two substances which chemists have yet extracted from this remarkable plant.

a. The volatile oil.—When distilled with water, the dried leaves and flowers, like those of the hop, yield a volatile oil in small quantity. The properties of this volatile oil, and its action upon the system, have not been studied. It is not supposed, however, to have any important connection with the remarkable effects of the plant upon the living animal.

b. The natural resin.—But the whole hemp plant is impregnated, especially in warm climates, with a resinous substance in which most active virtues reside. When collected as it naturally exudes, this resin forms the churrus of India. It is extracted when the leaves are boiled with butter to form the basis of the haschisch, or when the dried plant is treated with alcohol to obtain the hemp extract. It is soft, dissolves readily both in alcohol and ether, and is separated from these liquids in the form of a white powder when the solutions are mixed with water. It has a warm, bitterish, acrid, somewhat balsamic taste, and a fragrant odour, especially when heated.

Both the resin which naturally exudes from the hemp plant, and the extract it yields to spirituous liquids, are probably mixtures of several substances possessed of different properties and relations to animal life. The remarkably complex composition of opium justifies such an opinion. And the analogy of the same substance makes it probable that the produce of the plant will differ in different localities and countries—so that the churrus of India, and the haschisch of Syria, may produce very different effects on the same constitution. But these points have not as yet been investigated either chemically or physiologically. This substance, therefore, holds out the promise of a rich and interesting harvest to future experimenters.

6°. Hemp compared with opium.—The extract of hemp differs considerably from opium, not only in its sensible properties, but in its effects upon the system. It does not lessen but rather excites the appetite. It does not occasion nausea, dryness of the tongue, constipation, or lessening of the secretions, and is not usually followed by that melancholy state of depression to which the opium-eater is subject. It differs also in causing dilatation of the pupil, and sometimes catalepsy, in stilling pain less than opium does, in less constantly producing sleep, in the peculiar inebriating quality it possesses, in the phantasmata it awakens, and in its aphrodisiac effects. It operates likewise in a smaller dose, and does not produce that apathy to external impressions by which opium is characterised. On the contrary, to the intellectual activity imparted by opium it adds a corresponding sensitiveness and activity of all the feelings, and of the senses both internal and external. From the effects of opium a man must be roused by shaking and bodily movement. Those of haschisch are allayed by gentle soothing, and bodily stillness. This drug seems, in fact, to be to the oriental a source of exquisite and *peculiar* enjoyment, which unfits him for the ordinary affairs of this rough life, and with which happily we are, in this part of the world, still altogether unacquainted.

It is impossible to form any estimate of the quantity of hemp, of hemp resin, or of the artificial extract which is now used in different parts of the world for purposes of indulgence. It must, however, be very large, since the plant is so employed in one form or another by probably not less than two or three hundred millions of the human race!

CHAPTER XIX.

THE NARCOTICS WE INDULGE IN.

THE BETEL-NUT AND THE PEPPERWORTS.

The betel-nut and betel palm; plantations of, in the East; extensive growth in Sumatra.—How this nut is used and prepared.—Fondness for the betel in India.—Sensible effects of betel-chewing; its narcotic effects; counteracts opium.—Constituents of the betel-nut; its astringent principle.—Consumption of betel.—Substitutes for betel.—Catechu and gambir extract; extending consumption of the latter.—The pepperworts.—Betel pepper or pawn.—Beauty of the plant, and its importance as an agricultural product.—Mode of cultivation.—Effects of the betel-pepper.—The intoxicating long pepper or ava.—Chemistry of the pepperworts.—Piperin; its use against fevers.—Grains of Paradise, or malagueta pepper; their use as a spice in Africa and in England.—Use in adulterating beer and spirituous liquors.

VIII. Betel-nut.—The Areca or Betel-Nut, or Pinang, is the seed of the *Areca catechu*, one of the most graceful species of palm. On the slopes of the Khasia mountains in the Himalaya, above the flat Bheels, where palms are numerous, " the cultivated areca raises its graceful head and feathery crown, like an arrow shot down from heaven, in luxuriance and beauty above the verdant slopes" —(Dr. Hooker). Almost everywhere in India it is extensively cultivated. In Ceylon, throughout Malabar, and higher up the coast, it is seen in vast plantations. The

produce of these plantations is of great importance. As every one chews betel, the consumption of areca nuts in India is incredibly great. It forms, therefore, a most important article of traffic.

Fig. 69.

Areca catechu.—The Betel-nut Palm.
Height, thirty feet.
Fruit, half the natural size.

In the Sunda Islands the areca palm grows wild. In the Philippines, the labourer is paid in betel rolls, as he is with coca leaves in some parts of Peru; and the betel-nut is one of the most valuable articles of produce in Sumatra. Whole shiploads are yearly sent off from the latter island to Malacca, Siam, and Cochin-China. The total export was, a few years ago, estimated at 80,000 or 90,000 piculs (each $133\frac{1}{3}$ lb. English), the greater part of which went to China.*

1°. How the Betel-nut is used.—The Betel-nut is about the size of a cherry, slightly pear-shaped, very hard, and externally not unlike a nutmeg of inferior quality. It is chewed along with the leaf of the betel pepper and a little quicklime, and a supply of each of these is often carried by the betel-chewer in a box, provided with compartments for the purpose. In describing his visit to the Sultan of Sooloo, Captain Wilkes says:—"On the left hand of the Sultan sat his two sons, on the right his councillors, while immediately behind him sat the carrier of his betel-nut

* Ten to twelve millions of pounds.

casket. The casket was made of filagree silver, about the size of a small tea-caddy, of oblong shape, and rounded at the top. It had three divisions—one for the nut, another for the leaf, and a third for the lime. Next to this official was the pipe-bearer, who did not appear to be held in equal estimation."*

In preparing the betel for chewing in India, the nut is cut into long narrow pieces, and rolled up in leaves of the betel pepper, previously dusted on one side with moist chunam (the quicklime of calcined shells). In Luçon, one of the Philippines, Meyen found in every corner of the house a little box or dish in which are kept the betel rolls (*buyos*), prepared for the day's consumption; and a buyo is there offered to every one who enters, just as a pinch of snuff or a pipe is with us. "Travellers, and those who work in the open air, carry the buyos for the day in little boxes or bags, as the Peruvians do their coca. The preparation of the betel falls on the female members of the family, who, during the forenoon, may generally be seen lying on the ground and making buyos. The consumption of these is very great. Every one who can afford it puts a fresh buyo in his mouth every hour, which he can chew and suck for half an hour at least."† Persons who have lost their teeth have the ingredients ground up into a paste, so as to render chewing unnecessary.

The fondness for the betel in these eastern countries amounts to something like a passion. It is spoken of with enthusiasm. Many would rather forego both meat and drink than their favourite betel—(BLUME). The Tagali maidens regard it as a proof of the uprightness of the intentions of a lover, and of the strength of his affection, if he take the buyo from his mouth—(MEYEN). The betel-nut is

* *United States' Exploring Expedition* (London edition), vol. ii. p. 277.

† MEYEN, *Geography of Plants* (Ray Society), p. 352.

to the Eastern Archipelago what the coca is to Eastern Peru.

2°. Effects of the Betel-nut.—The visible effects of the betel are, that it promotes the flow of the saliva, and lessens the perspiration from the skin. It tinges the saliva red; so that when spit out, it falls on the earth like blood. It gives a red colour to the mouth, teeth, and lips, which, though at first sight disgusting to Europeans, is by the natives considered ornamental. It imparts also an agreeable odour to the breath, and is supposed to fasten the teeth, cleanse the gums, and cool the mouth. The juice is usually, but not always, swallowed.

Its effects as a narcotic have not been so clearly detailed. To persons not accustomed to it, the nut is powerfully astringent in the mouth and the throat, and the quicklime often removes the skin, and deadens for a time the sense of taste. But it causes giddiness when chewed to any extent. On those who are accustomed to use it, however, the betel produces weak but continuous and sustained exhilarating effects. And that these are of a most agreeable kind, may be inferred from the very extended area over which the chewing of betel prevails among the Asiatic nations. In the damp and pestilent regions of India, also, where the natives live upon a spare and miserable diet, it is really very conducive to health. Part of its healthful influence in fever-breeding districts is probably to be ascribed to the pepper-leaf which is chewed along with the betel-nut.

Its alleged effect in rousing persons who are under the influence of opium, as tea counteracts that of spirituous liquors, is somewhat remarkable. During the visit of Captain Wilkes to the Sultan of Sooloo, he had the opportunity of seeing the betel used for this purpose. That sultan's son, shortly after taking a few whiffs from. the opium-pipe, was entirely overcome, and became stupid and listless.

When but partially recovered from the stupor, he called for his betel-nut, *to revive him by its exciting effects.* This was carefully chewed by his attendant to a proper consistency, moulded into a ball, and then slipped into his mouth.

3°. CONSTITUENTS OF THE BETEL-NUT.—The chemistry of the Betel-nut is quite obscure. It is very astringent, and abounds in a peculiar species of tannin, which is extracted in India by boiling the nut in water, and is brought to this country under the name of *catechu.* In the moist, relaxing climates of the East, this strongly astringent substance acts beneficially upon the system. To it are probably to be ascribed some of the good effects experienced by Perron, who states that he "preserved his health, during a long and difficult voyage, by the habitual use of betel; while his companions who did not use it died mostly of dysentery."

But the ordinary and understood action of a merely astringent substance does not account for the giddiness caused by the betel-nut in a young chewer, nor for the gentle intoxication it produces in all. These properties seem to imply the presence in the nut of some narcotic ingredient which is as yet unknown. From the circumstance of no such substance having been yet discovered in the nut, some writers are inclined to ascribe the intoxicating influence of the buyos altogether to the pepper-leaf in which the nut is enclosed. Upon this point, however, we must suspend our judgment until the chemist has had an opportunity of submitting both nut and leaf to a rigorous chemical examination. My own opinion is, that the coveted effect upon the system is the result of the combined influence—first, of the constituents of the nut; second, of those of the fresh pepper; and, third, of substances which are produced or evolved in the mouth in consequence of the chemical action of the lime and of the saliva upon the ingredients of both nut and

leaf. Upon all this, light will no doubt be thrown before a long time elapses.

4°. CONSUMPTION OF BETEL.—We have no means of estimating the absolute quantity of this nut which is consumed yearly by the Asiatic nations; but it must be very great. It is chewed by probably not less than fifty millions of men! If we allow to each chewer ten pounds weight a-year, which is less than half an ounce a-day, this would give the enormous consumption of five hundred millions of pounds' weight every year! Only tobacco, among the narcotics in common use, is used in larger quantity than this.

The small quantity of the betel-nut imported into this country is converted into charcoal for tooth-powder, probably from some imaginary idea that it is superior for this purpose to other kinds of charcoal.

IX. SUBSTITUTES FOR BETEL.—As substitutes for the betel-nut, astringent extracts are coming into extensive use in the East. Thus—

a. The *catechu*, which is extracted, as above described, by boiling the areca nut, is extensively chewed in India, in place of the nut itself. It is there called *cashu*, and is known in this country by the older name of *Terra Japonica*.

In the north of India, towards the foot of the Himalayas, a similar catechu is extracted by boiling the wood of the Mimosa catechu, which grows wild there and in Ava. This is chewed in the same way as the areca catechu.

b. The *gambir* extract—which greatly resembles the *Terra Japonica*, but has a sweetish taste, and is still more astringent—is another substitute for the nut. The *Nauclea gambir*, and *N. aculeata*, are shrubs six or seven feet in height, the leaves of which, by boiling with water, yield the gambir extract. In the island of Sumatra, in Java and the other Dutch colonies, in India, Malacca, Singapore, and

many other localities, large plantations of these shrubs exist. The leaves are gathered from two to four times a year, and are boiled with water for five or six hours in iron kettles. The decanted liquor is then thickened by further boiling, and poured into moulds, when it hardens. This extract is of a blackish-brown colour, has at first a sweetish taste, and a pleasant aromatic flavour, which afterwards becomes astringent and bitter. It is chewed by the Malays in Sumatra, and in the Dutch colonies generally, in place of, or along with, the betel-nut; and the use of it is said to be rapidly extending throughout India.

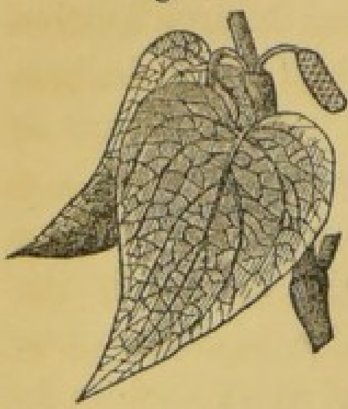
Very salutary virtues are ascribed to the gambir extract, and it is said especially to assist digestion. It is no doubt a mixed substance, containing several chemical ingredients. It has not, however, been chemically investigated; so that what it contains in addition to the astringent principle, or whether it possesses any narcotic virtues, we have as yet no means of knowing. The quality, and probably the composition, varies in different localities. The most esteemed samples are those from Penang and the coast of Bengal.

In 1833 the quantity of this substance produced on the island of Penang alone amounted to seventy thousand piculs, and in Singapore to twenty thousand—or together, to ten millions of pounds—(MEYEN). The production in these localities was at that time rapidly extending, so that the total Eastern consumption must now, in 1854, be something quite enormous.

X. THE PEPPERWORTS.—Various species of pepper are known to be possessed of narcotic properties, and several of these are in constant and most extensive use in tropical countries. The pepperworts are for the most part climbing plants, and where they grow wild, frequently strangle the tree they embrace.

1°. THE BETEL PEPPER OR PAWN.—The leaf of the betel pepper (*Chavica betle and C. Siraboa*), fig. 70, is always chewed along with the betel-nut, as above described. The almost universal use of the betel-nut makes the culture of this pepper one of great importance in the East, especially in the neighbourhood of large towns. Every person who possesses a little bit of land usually grows the leaves for his own consumption; and it may often be seen clinging round the stems of the beautiful betel palms which overshadow their dwellings. But in the towns, incredible quantities are every day sold in the markets, and piles of the leaves, three or four feet high, are carried about in baskets. The plantations of betel pepper are laid out like our bean-fields, but the plants stand eighteen inches apart, and their large, beautiful, heart-shaped leaves give the whole field a bright green colour, such as belongs to few other plants. They require much water, and are allowed to climb on poles like hops for the first eighteen months. They are then detached, and are directed round fast-growing young trees, which have meanwhile been planted between them. The leaves may be gathered in the third or fourth year, and the plants bear for six or seven years, after which they die and must be replaced.—(MEYEN).

fig. 70.



Chavica betle—The Betel leaf, or Betel Pepper. Scale, 1 inch to 3 inches.

In Northern India, and towards the Himalayas, the plant, though in almost equal demand, cannot be cultivated in the open fields, and is therefore raised under cover where the atmosphere is sufficiently moist. Dr. Hooker, when travelling on the banks of the Mahanuddee, towards the foot of the Himalayas, observed some curious low sheds erected for the growth of pawn or betel-pepper. These sheds were

twenty to fifty yards long, eight or twelve broad, and scarcely four feet high. They were of bamboo, wattled all round, and over the top. Inside the sheds slender upright rods were placed a few feet apart, up which the pepper climbed, and speedily filled the place with their deep green glossy foliage. The native enters every morning and carefully cleans the plants. Great attention is paid to them, as they would not live twenty-four hours if exposed to the open air; but the cultivation is, nevertheless, very profitable. This mode of culture extensively prevails.

I have already described the effects of the betel-chewing in general. What portion of these effects is due to the pepper-leaf in which the nut is wrapped up, has been experimentally ascertained. But as other varieties of pepper, which are used alone, are known to possess narcotic properties, some are inclined to ascribe the greater part of the peculiar influence of betel-chewing to this pepper-leaf. I do not coincide with this opinion. As I have already explained, the observed effects are, in the present state of our knowledge, to be ascribed rather to the conjoined influence of the constituents of both nut and leaf, and to the chemical action of the quicklime used along with them, and of the saliva upon both.

2°. THE INTOXICATING LONG PEPPER.—The narcotic effects of the Ava, or *Macropiper methysticum*, are more certain and more celebrated.

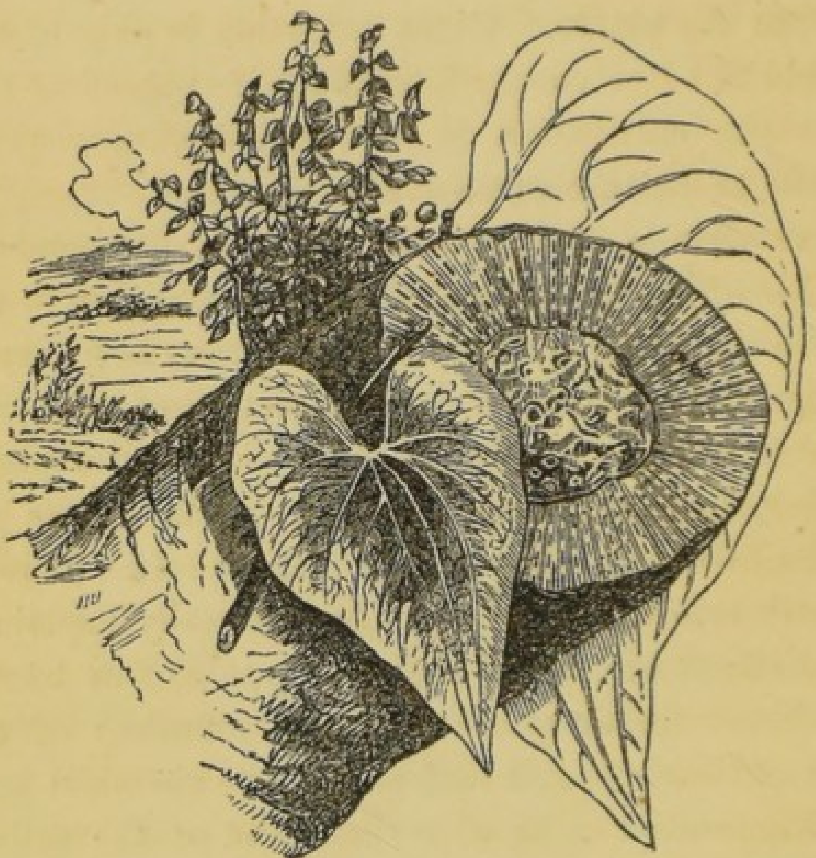
This plant has a thick, woody, rugged, aromatic woodstalk, which, when reduced to a pulp and then steeped in water, forms an intoxicating beverage.* This is in extensive use among the South Sea Islanders, both as a medicine and as an inebriating indulgence. It possesses a recognised narcotic influence, which is derived from some ingredient contained in the root. The same ingredient probably exists in

* See THE LIQUORS WE FERMENT.

the leaves, which are chewed along with the betel-nut in stead of those of the betel-pepper.

The roots and thickest parts of the stems of long pepper, cut into small pieces and dried, form a considerable

fig. 71.



Macropiper methysticum—The Ava Pepper shrub.
Scale, 1 inch to 3 feet.
Leaf, 1 inch to 2 inches. Outline of leaf, natural size.
Part of stem and root, showing section, natural size.

article of commerce all over India, under the name of *Pipula moola ;** but I am not aware if they are used for narcotic or intoxicating purposes.

Of the chemistry of the pepperworts we as yet know comparatively little. They all yield, when distilled with water, a volatile oil, which has the taste and smell of pepper. This oil is colourless, and is usually of the same chemical

* Pereira, *Materia Medica*, p. 1260

composition as the oils of turpentine, lemons, and orange-peel or neroli. Alcohol extracts from the pepperworts several resinous substances, which possess the acrid properties of pepper in great perfection. But they all contain, besides these, a solid white crystallisable substance known by the name of Piperin, which is said to equal quinine in its influence over intermittent fevers. All the three constituents, indeed, which I have mentioned—the oil, the resin, and the piperin—exercise a beneficial action in cases of intermittent fever; and to this action we are safe, I think, in ascribing a portion at least of their salutary influence in tropical regions. While in betel-chewing the astringent principle of the nut checks the tendency to internal relaxation, the fever-chasing principles of the pepper leaf preserve the health amid the steaming vapours which the hot sun draws forth from swamps and jungles and irrigated paddy-fields.

3°. GRAINS OF PARADISE.—Guinea grains of Malagueta pepper are the seeds, not of a pepperwort, but of a species of Cardamum (*Amomum melegueta*). They are imported from the coast of Guinea, where they are used by the natives as a spice for seasoning their food, and are held in great esteem. The seeds are small and angular, and consist of a glossy dark-brown husk, enclosing a perfectly white kernel which has a hot, pungent, peppery taste. In Africa they are considered to be exceedingly wholesome.

Grains of paradise were also very anciently in use as a spice in English cookery. The ancient fee-favour of the city of Norwich is twenty-four herring pies, each containing five herrings, to be carried to court by the lord of the manor of Carleton! In 1629 these pies were described as being seasoned with half a pound of ginger, half a pound of pepper, a quarter of a pound of cinnamon, one ounce of cloves, one ounce of long pepper, half an ounce of *grains of paradise*, and half an ounce of galangals. I am not aware that

they are now in use anywhere in England for the seasoning of food.

About forty thousand pounds of this seed are at present imported yearly into England. With the exception of what is used in veterinary medicine, all this is said to be employed for the purpose of imparting a fictitious appearance of strength to malt and spirituous liquors. By 56 Geo. III. c. 58, "no brewer or dealer in beer shall have in his possession or use grains of paradise, under a penalty of £200 for each offence; and no druggist shall sell the substance to a brewer under a penalty of £500 for each offence. Nevertheless, it is both sold and used, principally along with capsicum and juniper berries, to give a hot strong flavour to London gin; and along with Cocculus indicus and other bitters, to give a relish and warmth to country beer. In passing through Staffordshire some time ago, I was assured by a person connected with a large manufactory, that he had himself seen, in a druggist's shop, as much as ten pounds of grains of paradise sold to a single customer, for putting into beer.

The effect of hot substances like this in giving to liquors the appearance of strength, is illustrated by the qualities of a drink prepared in some of the Turkish provinces. A greatly esteemed liquor is there made by digesting mint and pimento in water. This liquor possesses so much of what is taken for alcoholic strength, that the person who drinks it for the first time supposes he has swallowed "the most ardent alcohol." No wonder the iron smelters and puddlers of Staffordshire drink beer three whole days out of the fortnight, if their thirst be provoked by grains of paradise, so that the more they drink, the thirstier they become! It is satisfactory to think, however, that though a provoker to drunkenness, this adulteration is not known to be poisonous in itself.

But the chemistry of this seed is still unknown. It has not hitherto been chemically examined, so that we do not know either what peculiar principles it contains, or what special physiological action it exercises upon the system.

CHAPTER XX.

THE NARCOTICS WE INDULGE IN.

COCA.

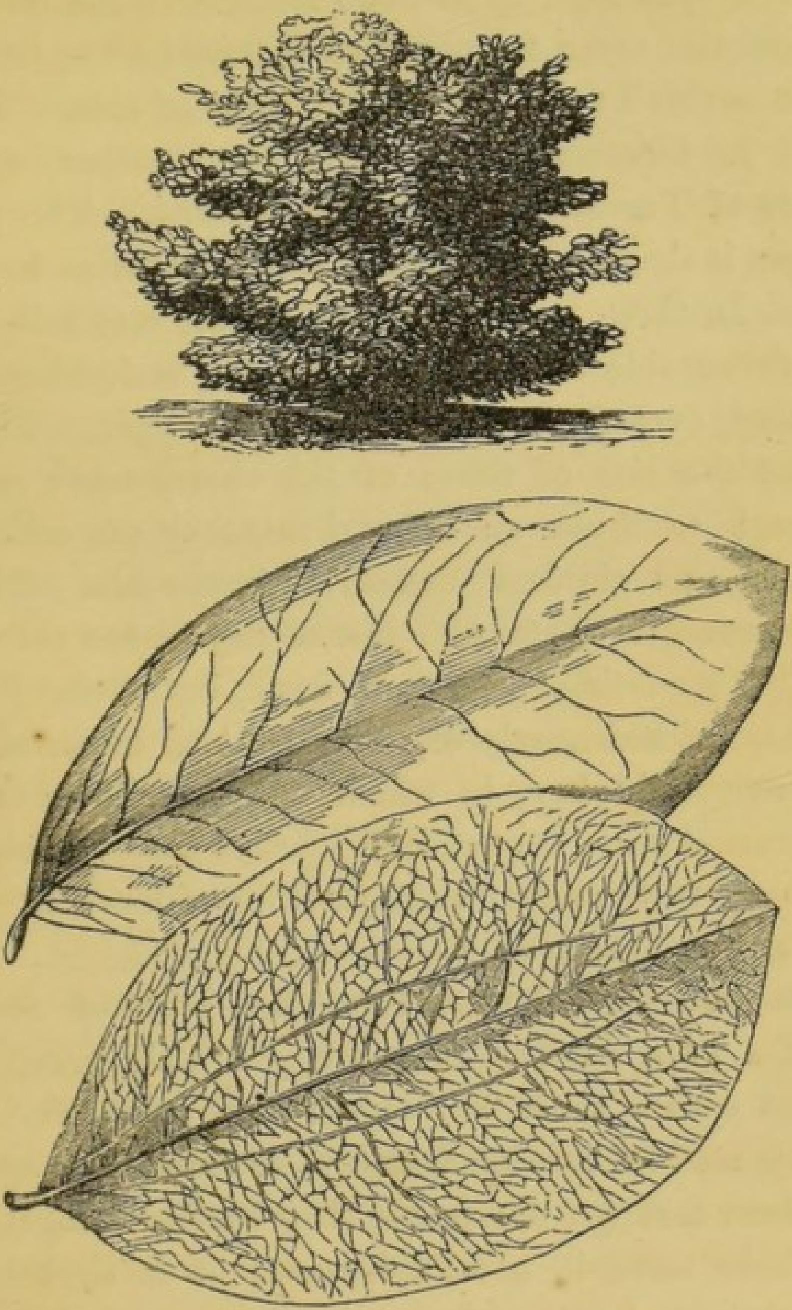
Coca, the narcotic of the Andes; description of the plant; mode of cultivation.—Ancient use of the coca leaf; its necessity to the Indian of Peru; how he uses it; its remarkable effects.—Melancholy temperament of the Indian.—Testimony of Von Tschudi and Dr. Weddell.—General effects of the coca leaf.—Intolerable craving of the confirmed coquero.—Evil effects of the coca leaf.—Testimony of Pöppig and other travellers.—Opinions of old Spanish writers.—Indian reverence for the plant its characteristic effects.—Lessens the necessity for ordinary food.—Prevents difficulty of breathing in ascending hills.—Experience and testimony of Von Tschudi.—Its introduction into Europe recommended.—Chemical history of the coca leaf.—The odoriferous resin.—The bitter principle.—The tannic acid.—How the coca leaf acts.—Difficulties as to its action.—How it resembles tea, the hop, hemp, and opium.—Like opium, it sustains and inclines to retirement.—Consumption of coca.—Probable extent and money value of the yearly growth of coca.

Coca, the narcotic of the Andes, is not less interesting than the narcotics of the East, either in its social or in its physiological relations. It is little known in Europe—its use as an indulgence being in a great measure confined to the native Indians of Bolivia and Peru.

The *Erythroxylon coca* is a bush which attains the height of six or eight feet, and resembles the black thorn in its small white flowers and bright green leaves (fig. 72). It is a native of the tropical valleys which occur on the

eastern slope of the Andes, in Bolivia and Peru, and it still grows wild in many parts of these countries. That

Fig. 72.



Erythroxylon coca—The Coca-leaf plant.

Scale, 1 inch to 3 feet.

Coca leaf, natural size, showing the upper and under sides of the leaf. The under side exhibits the remarkable arched line on each side of the midrib by which this leaf is distinguished.

which is used by the people, however, is chiefly the produce of cultivation. In the inhabited parts of the above valleys

it forms an important agricultural crop. Like our common thorn, it is raised in seed beds, from which it is planted out into regularly arranged coca-plantations. The steep sides of the valleys, as high up as 8000 feet above the level of the sea, where the mean temperature is from 64° to 68° Fahr., are often covered with these plantations of coca. They are arranged in terraces rising above one another, as in the vineyards of Tuscany and the Holy Land. The province of Yongas is the principal seat of this cultivation in Eastern Bolivia. In three years the bushes come into full bearing, and in favourable localities yield three, and, where irrigation is used, even four crops of leaves in a year. The leaves are about the size of those of the cherry-tree; and when ripe enough to break on being bent, they are collected by the women and children, and dried in the sun. The total produce averages about 800 lbs. of dry leaves per English acre. It is sometimes one half more, but often also very much less. When nearly dry they emit an odour similar to that of new-made hay, in which much mellilot or sweet-scented vernal grass is contained; hence they occasion headaches among new-comers, as haymaking does with delicate persons among ourselves.

These sun-dried leaves form the coca of commerce. When of a good quality they are of a pale green colour. Dampness causes them to become dark coloured, in which state they are less esteemed, and their smell less agreeable. If they heat through dampness, they become altogether useless. Their taste is not unpleasant; it is slightly bitter and aromatic, and resembles that of green tea of inferior quality. It becomes more piquant and agreeable when a sprinkling of quicklime or plant ashes is chewed along with them.

1°. Ancient use of the coca leaf.—The use of this plant among the Indians of South America dates from very

remote periods. When the Spanish conquerors overcame the native races of the hilly country of Peru, they found extensive plantations of an herb called coca.* And they observed among these races the singular custom of chewing the leaves of this plant during frequent short periods of repose, specially set apart for the purpose. So general, indeed, was the use of this plant, and so common the demand for it, that it formed the usual money, or medium of exchange, in Peru.† The practice of using this plant was already ancient among the Indian races, and its origin was lost in the mists of remote antiquity. After the introduction of gold and silver money it became the principal article of traffic. Its cultivation was a care of the native governments during the reign of the Incas, and it continues equally prevalent to the present day. The beloved leaf is still to the Indian of the mountains the delight, the support, and in some measure the necessity of his life. He is never seen without the leathern pouch (his *chuspa*), to contain his coca leaves, and his little gourd-bottle to hold powdered unslacked lime—or, if he is a Bolivian, the alkaline ashes of the quinoa, of the musa root, or of certain other plants.

When preparing to *acullicar*, or chew, he first makes himself as comfortable as circumstances will permit. He lays down his burden, if he has one; he seats himself, and putting his chuspa between his knees, he pulls out, one by one, the leaves which are to form his new ball. The attention he gives to this operation is worthy of remark. The satisfaction with which he dips his hand into the midst of the leaves of a full chuspa, and the regret with which he

* The word *Coca* is derived from the Aymara (Indian) word Khoka, signifying "plant," in the same way as in Paraguay the indigenous tea-plant is called *Yerba*, "*the* plant" par excellence.

† As tobacco does now among the Damaras, Ovampo, and other tribes of South-Western Africa, lately visited by Mr. Galton.—See his *Tropical South Africa*, p. 206.

looks upon his little bag when it is nearly empty—these little things prove that to the Indian the custom is a source of real happiness, and not the mere consequence of a want—(WEDDELL). Always three, and sometimes four times a-day, he rests from his mining or other labour, or pauses in his journey, and lays down his burden, to chew in quiet the beloved leaf.

When riding, or walking, or labouring, the leaves have little effect. As with opium and hemp, stillness and repose are indispensable to his full enjoyment of the luxury it produces. In the shade of a tree he stretches himself at ease, and from time to time puts into his mouth a few leaves rolled into a ball (an *acullico*), and after each new supply a little unslacked lime on the end of a slip of wood moistened and dipped into his lime-flask. This brings out the *true taste* of the leaf, and causes a copious flow of greenish-coloured saliva, which is partly rejected and partly swallowed. When the ball ceases to emit juice it is thrown away, and a new supply is taken.

The interval of enjoyment conceded to the labouring Indian lasts from fifteen minutes to half an hour, and is generally wound up by the smoking of a paper cigar. Repeated three or four times a-day, his average consumption of coca is an ounce or an ounce and a half in the twenty-four hours, and on holidays double that quantity. The owners of mines and plantations have long found it for their interest to allow a suspension of labour three times a-day for the *chaccar*, as it is called ; and the Indian speedily quits an employer who endeavours to stint or deprive him of these periods of indulgence. During these periods his *phlegm* is something marvellous. No degree of urgency or entreaty on the part of his master or employer will move him ; while the confirmed *coquero*, when under the influence of the leaf, is heedless of the thunderstorm which threatens to drown him

where he lies, of the roar of approaching wild beasts, or of the smoking fire which creeps along the grass and is about to suffocate or scorch him in his lair.

The Indians of the Peruvian Andes are subject to fits of melancholy, or are generally perhaps of a gloomy temperament. "In their domestic relations," says Von Tschudi, "the Indians are unsocial and gloomy. Husband, wife, and children live together with but little appearance of affection. The children seem to approach their parents timidly, and whole days sometimes elapse without the interchange of a word of kindness between them. When not engaged in out-door work, the Indian sits gloomily in his hut, chewing coca and brooding silently over his own thoughts."*

Dr. Weddell, who has lately travelled in Bolivia, bears a similar testimony in regard to the appearance and manners of these people. "It is difficult," he says, "to have lived for any time among these men, without being struck by the expression of concentrated melancholy which can be read upon their features, and which seems to speak of an undefined but constant suffering. This physiognomy is, above all, remarkable among the Aymaras, whose character is also more taciturn than that of the Quichuas, who inhabit along with them the table-lands of the Andes."†

One would have supposed that when the free republics of South America were established, the trials of the long-oppressed aborigines would have been at an end, and that something like political equality would have been established among the different races. But such is not the case. In Bolivia, every Indian from eighteen to fifty years of age is subjected to a poll-tax of five dollars if he is a labourer, and from six to ten if he is a proprietor; and this tax is collect-

* *Travels in Peru*, 1838 *to* 1842, p. 450. London, 1847.

† WEDDELL. *Voyage dans le Nord de la Bolivie.* Paris, 1853. P. 61.

ed half-yearly. No equivalent tax is imposed upon the whites, and from this source four and a half millions of dollars are derived—the total yearly revenue of the republic being only ten and a half millions. The unhappy race, therefore, is still ground down by the dominant blood, and the melancholy feeling of inferiority is still perpetuated.

It does not appear, however, that the coca adds to the gloom of the unhappy Indian; on the contrary, he takes it to relieve himself for the time from the peculiarities of his temperament. Silence and abstraction are necessary to the enjoyment, but the use of it makes him cheerful; and it is to the unhappy, often oppressed, and always poor Peruvian, the source of his highest pleasures. It has come down to him as a relic of the ancient enjoyments of his people, and during the fantasy it produces, he participates in scenes and pleasures from which in common life he is altogether excluded. Dr. Weddell very sensibly remarks, that, as a relic of the past, he attaches "superstitious ideas to the coca, which must triple, in his imagination, the benefits he receives from it," and that its value to him is further enhanced by its being the "sole and only distraction which breaks the incomparable monotony of his existence."

2°. General effects of the Coca leaf.—The coca leaf acts differently according to the way in which it is used. When infused and drunk like tea, it produces a gentle excitement, followed by wakefulness; and, if taken strong, retards the approach of hunger, prevents the usual breathlessness in climbing hills, and, in large doses, dilates the pupil and renders the eye intolerant of light. It is seldom used in this way, however, but is usually chewed in the form of a ball or quid, which is turned over and over in the mouth as is done with tobacco. In this way its action is more gradual and prolonged than when the infusion only is taken. It is also very different in its character, because the constant

chewing, the continued action of the saliva, and the influence of the lime or ashes chewed along with it, extract from the leaf certain other active constituents which water alone does not dissolve when it is infused after the manner of tea.

The cultivation and use of the coca has extended from the slopes of the Andes eastward, to different parts of Brazil, and to the river of the Amazons. But here it is used somewhat differently. The leaves are dried and reduced to powder in a wooden mortar along with the ash of the leaves of *Cecropia peltata*, and in this mixed state are preserved for use. From time to time a portion of this greenish grey powder is introduced into the mouth, especially when it is desired to overcome hunger or drowsiness. It augments the secretion of saliva, produces a sensation of fulness and warmth in the mouth, stills hunger, and increases bodily activity.

We have no detailed account, by an actual chewer of the leaf, of the *special* effects which it produces; but these must be very seducing, since, though long stigmatised, and still very generally considered as a degrading, purely Indian, and therefore despicable vice, many white Peruvians at Lima and elsewhere retire daily at stated times to chew the coca. Even Europeans in different parts of the country have fallen into the habit. A confirmed chewer of coca is called a "coquero," and he is said to become occasionally more thoroughly a slave to the leaf than the inveterate drunkard is to spirituous liquors.

Sometimes the coquero is overtaken by a craving which he cannot resist, and he betakes himself for days together to the silence of the woods, and there indulges unrestrained in the use of the weed. Young men of the best families in Peru become sometimes addicted to this extreme degree of excess, and are then considered as lost. Forsaking cities and the company of civilised men, and living chiefly in

woods or in Indian villages, they give themselves up to a savage and solitary life. Hence the term, a *white coquero*, has there something of the same evil sense as irreclaimable drunkard has with us.

The chewing of coca gives "a bad breath (abominable, according to Weddell), pale lips and gums, greenish and stumpy teeth, and an ugly black mark at the angles of the mouth. The inveterate coquero is known at the first glance. His unsteady gait, his yellow skin, his dim and sunken eyes encircled by a purple ring, his quivering lips, and his general apathy, all bear evidence of the baneful effects of the coca juice when taken in excess."—(VON TSCHUDI.)

Its first evil effect is to weaken the digestion; it then gradually induces a disease locally named the *opilacion*. Biliary affections, with all the painful symptoms which attend them in tropical climates, and, above all, gall stones, are frequent and severe. The appetite becomes exceedingly uncertain, till at length the dislike to all food is succeeded by an inordinate appetite for animal excrement. Then dropsical swellings and boils come on; and the patient, if he can get it, flies to brandy for relief, and thus drags out a few miserable years, till death relieves him.*

These descriptions are sufficiently repulsive, but they exhibit only the dark side of the picture. A similar representation could be truthfully made of the evil effects of wine or beer in too numerous cases, without thereby implying that these liquors ought either to be wholly forbidden, or of our own accord entirely given up. Where coca was most in use, Dr. Weddell states that he met with none of the extreme cases mentioned by Pöppig. The chewing of the leaf, he says, produces ill effects sometimes upon Europeans who have not contracted the habit in their youth. And in

* PÖPPIG, *Reise in Chile, Peru und auf dem Amazon Ström*, 1827 *to* 1832 chap. iv.

two or three cases which came under his observation, he ascribed to the abuse of it the production of a "peculiar aberration of the intellectual faculties characterised by hallucinations." Von Tschudi also, as the sum of his inquiries, says: "Setting aside all extravagant and visionary notions on the subject, I am clearly of opinion that the moderate use of coca is not merely innoxious, but that it may even be very conducive to health. In support of this conclusion, I may refer to the numerous examples of longevity among Indians who, almost from the age of boyhood, have been in the habit of masticating coca three times a-day. Cases are not unfrequent of Indians attaining the great age of 130 years; and these men, at the ordinary rate of consumption, must in the course of their lives have chewed not less than 2700 lbs. of the leaf, and yet have retained perfect health. Even the Indian coquero, who takes it in excess, reaches the age of fifty years. It is consumed both more abundantly, however, and with less baneful results, in the higher Andes than in the lower and warmer regions."

It is certain that the Peruvian Indians have always ascribed to it the most extraordinary virtues. Clusius, writing in 1605, says thas wken he asked the Indians why they always had the coca in their mouths, the answer was, that, when using it, neither hunger nor thirst annoyed them, while their strength and vigour were confirmed; and Dr. Unanui, in the title of his Dissertation on the plant (Lima, 1794), speaks of it as "La famosa planta del Peru nombrada coca."

At the present day the Indians still regard it as some thing sacred and mysterious. This impression they have probably inherited as a fragment of their ancient religion, for in all the ceremonies, whether warlike or religious, of the times of the Incas, the coca was introduced. It was used by the priests either for producing smoke at the great

offerings to the gods, for throwing in handfuls upon the sacrifice, or as the sacrifice itself.

"During divine worship the priests chewed coca leaves, and unless they were supplied with them, it was believed that the favour of the gods could not be propitiated. It was also deemed necessary that the supplicator for divine grace should approach the priests with an acullico in his mouth. It was believed that any business undertaken without the benediction of coca leaves could not prosper, and to the shrub itself worship was rendered. During an interval of more than three hundred years Christianity has not been able to subdue this deep-rooted idolatry, for everywhere we find traces of belief in the mysterious powers of this plant. The excavators in the mines of Cerro de Pasco throw chewed coca on hard veins of metal, in the belief that it softens the ore and renders it more easy to work. The origin of this custom is easily explained, when it is recollected that in the time of the Incas it was believed that the *cozas*—the deities of metals—rendered the mountains impenetrable if they were not propitiated by the odour of coca. The Indians, even at the present time, put coca leaves into the mouths of dead persons, to secure to them a favourable reception on their entrance into another world; and when a Peruvian Indian on a journey falls in with a mummy, he, with timid reverence, presents to it some coca leaves as his pious offering.—(VON TSCHUDI.)

3°. CHARACTERISTIC EFFECTS OF THE COCA LEAF.—Even those Europeans who are best acquainted with the Indian races, and have seen most of the action of this plant upon them, do not deny that, in addition to the ordinary properties of a weak narcotic, the coca leaves possess two extraordinary qualities not known to co-exist in any other substance. These are—

First, That when chewed they lessen the desire, and ap-

parently the necessity also, for ordinary food They not only enable the chewer, as brandy and opium do, to put forth a greater nervous energy for a short time, but actually, with the same amount of food, perseveringly to undergo more laborious fatigue or longer-continued labour. With a feeble ration of dried maize, or barley crushed into flour, the Indian, if duly supplied with coca, toils under heavy burdens, day after day, up the steep slopes of the mountain passes; or digs for years in the subterranean mines, insensible to weariness, to cold, or to hunger. He believes, indeed, that it may be made a substitute for food altogether; and an instance given by Von Tschudi seems almost to justify this opinion.

"A cholo of Huari, named Hatan Huamang, was employed by me in very laborious digging. During the five days and nights he was in my service he never tasted any food, and took only two hours' sleep each night. But at intervals of two and a half or three hours he regularly chewed about half an ounce of coca leaves, and he kept an acullico continually in his mouth. I was constantly beside him, and therefore I had the opportunity of closely observing him. The work for which I had engaged him being finished, he accompanied me on a two days' journey of twenty-three leagues across the level heights. Though on foot, he kept up with the pace of my mule, and halted only for the *chaccar*. On leaving me, he declared he would willingly engage himself again for the same amount of work, and that he would go through it without food, if I would but allow him a sufficient supply of coca. The village priest assured me that this man was sixty-two years of age, and that he had never known him to be ill in his life."

How this remarkable effect of the coca is to be accounted for, in accordance with received notions on the subject of animal nutrition, it is not easy to see. Dr. Weddell,

who is less decided in his praise of the virtues of the leaf, says that the facts in favour of the opinion that it is capable of supporting the strength, in the absence of all other nourishment, have been advanced by so many persons worthy of credit, that we must push our scepticism very far if we are to doubt them. He asserts, however, that, as commonly used, coca does not *satisfy the appetite.* The Indians who accompanied him in his tour, though they chewed all day, yet at night ate like hungry men, and sometimes at a single meal swallowed as much as would serve him two days. The power of enabling them to support abstinence, therefore, is all he is willing, from his limited experience, to concede to the plant. It produces, he says, a peculiar excitement, slow and sustained, not like that of tea and coffee, exercised chiefly on the brain, but diffused generally over the nervous system.

The least we can concede to the plant, therefore, seems to be, that it enables the body to feed upon itself, so to speak, for a length of time, without the hunger-pains and weakness which usually accompany the prolonged abstinence from ordinary food.

Second, The other extraordinary property of the leaf is, that, either when chewed or when taken in the form of infusion, like tea, it prevents the occurrence of that difficulty of respiration which is usually felt in ascending the long and steep slopes of the Cordillera and the Puna.

"When I was in the Puna," says Von Tschudi, "at the height of fourteen thousand feet above the level of the sea, I drank always, before going out to hunt, a strong infusion of coca leaves. I could then, during the whole day, climb the heights and follow the swift-footed wild animals, without experiencing any greater difficulty of breathing than I should have felt in similar rapid movements on the coast. Moreover, I did not suffer from the symptoms of cerebral excite-

ment or uneasiness which other travellers have experienced. The reason perhaps is, that I only drank the decoction on the cold Puna, where the nervous system is far less susceptible than in the climate of the forests beneath. However, I always felt a sense of great satiety after taking the coca infusion, and I did not feel a desire for my next meal until after the time at which I usually took it."

The reason of this action of the leaf is not less difficult to make out than that of its alleged strength-sustaining capabilities.

When the Spanish conquerors took possession of Peru, the Indians and all their customs were treated by them with equal contempt; but every thing connected with their religion was especially denounced by the Spanish priests. Hence the use of coca was condemned and forbidden.

A council of the church denounced it in 1567 as a "worthless substance, fitted for the misuse and superstition of the Indians;" and a royal decree, in 1569, condemned the idea that coca gives strength, as an "illusion of the devil." But these fulminations were of no avail. The Peruvians still clung to their esteemed national leaf, and the owners of mines and plantations, discovering its efficacy in enabling their slaves to perform the heavy tasks they imposed upon them, soon became its warm defenders. Even churchmen at last came to regard it with indulgence, and, stranger still, to recommend its introduction into Europe.

One of the warmest advocates of the plant was the Jesuit Don Antonio Julian, who, in a work entitled *Perla de America*, laments that coca is not introduced into Europe instead of tea and coffee. "It is," he observes, "melancholy to reflect that the poor of Europe cannot obtain this preservative against hunger and thirst, and that our working people are not supported by this strengthening plant in their long-continued labours."

Dr. Don Pedro Nolasco Crespo, again, in a treatise published in 1793, insisted upon the advantages which might be derived from the introduction of the plant into the European navies. More recently Von Tschudi has also recommended it as fitted "to afford a nutritious refreshment to seamen in the exercise of their laborious duties, and to counteract the unwholesome effect of salt provisions." And, lastly, Professor Schlechtendal, who has lately written upon the coca, after commending it as a tonic, soothing, and nutritive—as preventing weakness of the stomach, and the obstructions, colic and hypochondria, to which such weakness gives rise—adds that, "without doubt, the leaves might be usefully employed in Europe."

With all this testimony in its favour, we may, I think, dismiss those fears of the coca leaf which old Spanish prejudices awakened, and which representations, like those of Pöppig, have tended to perpetuate in Europe. There is no good reason why it should not be tried among ourselves. In our climate, and after so long a sea voyage, no doubt its effects would be weaker than in its native country, but good may possibly follow from the use of it nevertheless.

4°. Chemical history of the Coca leaf.—Of the chemical history of this remarkable leaf we are as yet in a great measure ignorant. It is known, however, to contain at least three different constituents, upon the joint action of all of which the observed effects of the leaf probably in some measure depend. These are an odoriferous resinous substance, a bitter principle, and a species of tannic acid.

First, The odoriferous resin.—As they reach this country, the leaves are coated or smoothed over with a resinous or waxy substance, which is only sparingly soluble in water, but which ether readily dissolves. When digested in ether for the purpose of extracting this substance, a beautiful dark green solution is obtained, which, on being evaporated in the

open air, leaves a brownish resin, possessed of a powerful, peculiar, and penetrating odour. When exposed for a length of time to the air, this resinous matter diminishes in quantity, and gradually loses the whole of its smell, leaving a fusible, nearly inodorous matter behind. Ether therefore extracts at least two substances from the leaf, one of which is very volatile, and has a powerful odour. It is probable that in this volatile substance the narcotic qualities of the leaf reside. And this is consistent with the fact, that the leaves gradually lose their smell and virtue, and, after twelve months, are generally considered worthless; and with the assertion of those who live in the coca country, that only among them are the real virtues of the leaf ever experienced by the consumer. It is usual to make up leaves into hard packages, covered with fresh hides which shrink and compress the whole as they dry. But notwithstanding this close packing, resembling that of hard-pressed hop-pockets, they insensibly give off their volatile ingredients as hops do, and by transport and keeping continually diminish in value and estimation. The volatile resinous matter extracted by ether is, therefore, one of the most important ingredients of the coca leaf.—(JOHNSTON.)

Second, *The bitter principle*.—We have seen in a preceding chapter* that tea and coffee, besides the volatile ingredients to which their aroma is owing, contain a white, bitter, crystallisable substance known by the name of *theine;* and that to this theine the remarkable properties of these beverages are partly to be ascribed. Coca also contains a bitter principle, which alcohol is capable of dissolving out of the leaves.—(FREMY.) But this bitter compound does not crystallise, and has not yet been obtained in a pure state, or rigorously examined. It can scarcely be doubted

* See THE BEVERAGES WE INFUSE, pp. 141, 171.

that the effect of the leaf upon the coca-chewer is due in part to the presence of this coca bitter; but what is the exact nature of its action upon the system has not as yet been physiologically investigated.

Third. Besides these two substances, the coca leaf contains also a portion of a tannic acid, which, like the tannic acid of tea, gives a black colour with what are called *per* salts* of iron.—(WACKENRUDER.)

The proportions in which these several known ingredients occur in the leaf have not been determined.

5°. HOW THE COCA LEAF ACTS.—It will strike the reader that even this imperfect knowledge of the chemistry of the plant shows a singular analogy between the coca leaf, the hop flower, and the tea leaf of China. All contain a volatile, aroma-giving ingredient; in all a bitter principle exists; and from all of them a tannic acid can be extracted. Yet if, with this small amount of chemical knowledge—aided even by what we know of the action of tea and the hop—we attempt to explain the remarkable effects produced by the coca leaf, we utterly fail.

How the mere chewing of one or two ounces of these leaves in a day, partly rejecting and partly swallowing the saliva,† but wholly rejecting the chewed leaf—how this supports the strength, or can materially nourish the body in the ordinary acceptation of the term, we cannot understand. It cannot *give* much to the body; it must therefore act simply in preventing or greatly diminishing the ordinary and natural waste of the tissues which usually accompanies bodily exertion. As wine and tea act upon the nervous system of the aged, so as to restrain the natural waste to a quantity which the now weakened digestion can readily replace, and

* These are compounds of the *red* or *per*-oxide of iron with acids.

† Dr. Weddell states that the saliva is *never rejected;* and, being a later authority than Von Tschudi, whom I have followed in the text, he is probably correct.

thus maintain the weight of the body undiminished—so it is probably with coca. In the young and middle-aged it lessens the waste of the tissues, and thus enables a smaller supply of food to sustain the weight and strength of the body.

The coca leaf resembles that of hemp, in the narcotic quality of dilating the pupil, which opium does not possess. But, on the other hand, it resembles opium in the new strength it imparts to the worn and weary body. The Turkish courier, or the Cutchee horseman, under the influence of opium, reminds us of the Peruvian miner or muleteer who has plenty of coca. In spite of fatigue and exhaustion, both compel their failing limbs to new exertion, and, unconscious of new pain, accomplish most wonderful labours. And in the proneness of the coca eater to a solitary life we recognise an influence of this herb similar to that which opium exercises upon those who have experienced its highest enjoyments. It is alone and in retirement that the Eastern opium-eater finds his greatest pleasure. And in our own less sunny climate the same inclination appears to exist. "Markets and theatres," says De Quincey, "are not the appropriate haunts of the opium-eater when in the divinest state incident to his enjoyment. In that state crowds become an oppression to him, music even too sensual and gross. He naturally seeks solitude and silence as indispensable conditions of those trances or profoundest reveries, which are the crown and consummation of what opium can do for human nature. At that time I often fell into these reveries on taking opium; and more than once it has happened to me on a summer night, when I have been at an open window, in a room from which I could overlook the sea at a mile below me, and could command a view of the great town of L—— at about the same distance, that I have sat from sunset to sunrise, motionless, and without wishing to move.'

This description recalls exactly the picture of the confirmed coquero reclining for hours beneath his sheltering tree, absorbed, abstracted, and heedless of all external things. Whether his apathy and phlegm ever approached to that of the coquero, the English Opium-eater does not inform us.

6°. CONSUMPTION OF COCA LEAF.—We have no accurate data from which to form an estimate of the actual weight of coca leaf collected and consumed in Bolivia and Peru. Pöppig estimates the money value of the yearly produce to be about four and a half millions of Prussian dollars, which, at 1s. a pound, the price it yields to the grower, would make the annual produce nearly 15,000,000 lbs. This approximation is sufficient to show us its importance to the higher regions of South America, in an agricultural and commercial, as well as in a social point of view.

Dr. Weddell again, who has recently travelled in Bolivia, informs us that the province of Yongas, in Bolivia, in which the coca is much cultivated, alone produces 9,600,000 Spanish pounds. The total produce, therefore, is probably much beyond the 15,000,000 lbs. deduced from the statement of Pöppig.

The importance of the plant is shown also by another fact mentioned by the same traveller—that the revenue of the state of Bolivia, in 1850, amounted to ten and a half millions of francs, of which nine hundred thousand, or one-twelfth of the whole, is derived from the tax on coca. Had he told us the amount of the tax per pound, we should have been able to approximate more nearly to the total produce of the state of Bolivia.

When we consider that eastward from Bolivia and Peru, the culture and use of coca have extended into parts of Brazil and to the banks of the Amazon, it will not appear exaggerated if we estimate the actual growth and consumption

of the dried coca-leaf at 30,000,000 lbs. a-year. At 1s. a pound, this is worth a million and a-half sterling; and at the average produce of 800 lbs. an acre, it implies the use of 37,000 acres of good and carefully cultivated land for the growth of this plant. We may estimate also that the chewing of coca is more or less indulged in among about ten millions of the human race.

CHAPTER XXI.

THE NARCOTICS WE INDULGE IN.

THE THORN-APPLES, THE SIBERIAN FUNGUS, AND THE MINOR NARCOTICS.

The red thorn-apple; its use among the Indians of Peru; its remarkable effects; taken by the Indian priests; frenzy induced by it; used in the temples of the Andes and of Greece; Delphic oracles inspired by it; singular coincidence in priestly deceptions.—The common thorn-apple; its use in Europe for criminal purposes—In Russia, for giving headiness to beer; in India, to ardent spirits—How it is employed by the poisoners of India—Spectral illusions occasioned by the use of it—Narcotic qualities of the leaves.—Chemical history of the thorn-apples.—The poisonous daturin and the empyreumatic oil; their joint influence in smoking.—The Siberian fungus; how collected and used; its intoxicating effects; delusions created by it; its active principle escapes in the urine; may be again used repeatedly, and by different persons; Siberian custom.—The common puff-ball; narcotic qualities of its smoke when burning.—Chemistry of the poisonous fungi; they contain amanitin.—Empyreumatic oil of the burning puff-ball.—The minor narcotics: The emetic holly, the narcotic of Florida; how it is used.—The deadly nightshade; its remarkable effects; destruction of a Norwegian army in Scotland.—The common henbane.—The bearded darnel gives headiness to beer, and poisons bread.—Sweet gale; its use for giving bitterness to beer.—Heather beer of the Picts and Danes.—The rhododendrons, poisonous and narcotic.—The Azalea pontica gives its peculiar qualities to the Euxine or Trebizond honey.—The andromedas and kalmias of North America act as narcotics.—Poisoning by partridge flesh.—Narcotic effects of sweet odours on some constitutions.

XII. The Thorn-apples.—The history of the thorn-apples as familiar narcotics is no less interesting, and their effects upon the system not less remarkable, than those of

any of the substances I have hitherto described. Two species are known to be employed in different parts of the world.

1°. The Red Thorn-apple (*Datura sanguinea*), fig. 73, is in use among the Indians of the Andes, by some tribes of whom the coca leaf, already described, is principally consumed. It grows on the less steep slopes of the Andean valleys, and is called by the natives Bovachero, or Yerba de huaca. The fruit of the plant is the part employed, and from it the Indians prepare a strong narcotic drink, which they call Tonga. By the use of this drink they believe that they are brought into communication with the spirits of their forefathers. Von Tschudi had an opportunity of observing an Indian under the influence of this drug, and he thus describes its effects: "Shortly after having swallowed the beverage, he fell into a heavy stupor. He sat with his eyes vacantly fixed on the ground, his mouth convulsively closed, and his nostrils dilated. In the course of about a quarter of an hour his eyes began to roll, foam issued from his half-opened lips, and his whole body was agitated by frightful convulsions. These violent symptoms having subsided, a profound sleep of several hours succeeded. In the evening, when I

Fig. 73.

Datura sanguinea—The Red Thorn-Apple.
Scale, one inch to nine inches.

saw him again, he was relating to a circle of attentive listeners the particulars of his vision, during which he alleged he had held communication with the spirits of his forefathers. He appeared very weak and exhausted."*

In former times, the Indian priests, when they pretended to transport themselves into the presence of their deities, drank the juice of this thorn-apple, in order to excite themselves to a state of ecstasy. And although the establishment of Christianity has weaned the Indians from their idolatry, it has not yet banished their old superstitions. They still believe that they can hold communication with the spirits of their ancestors, and that they can obtain from them a clue to the treasures ooncealed in the *huacas*, or graves; hence the Indian name of the thorn-apple, Huaca-cachu—grave-plant—or Yerba de huaca.

When the decoction is taken very strong, it brings on attacks of furious excitement. The whole plant is narcotic, but it is in the seeds that the greatest virtue resides. These are said by some authors to have been used also by the priests of the Delphic temple in ancient Greece to produce those frenzied ravings which were then called prophecies. Such a practice certainly obtained in the Temple of the Sun at Sogamossa—(LINDLEY.) This Sogamossa is near Bogota, in the Andes of New Grenada.

It is sufficiently strange to see how similar modes and means of imposition were made use of by the priests of nearly every false religion in ancient times, for the purpose of deluding their credulous countrymen. But it is truly remarkable that among the mountains of Greece, in the palmiest days of that classic country, the same observed effects, of the same wild plant, should have been employed by the priests of Apollo to deceive the intellectual Greeks, as at the same time were daily used by the priests of the sun to

* VON TSCHUDI, *Travels in Peru*, p. 269.

deceive the rude and credulous Indians among the far distant mountains of the Andes. The pretended second-sight, and the other marvels told of the old seers of the Scottish Highlands, may owe their origin to nothing more noble or mysterious than a draught of thorn-apple, nightshade, or belladonna tea.

2°. THE COMMON THORN-APPLE (*Datura stramonium*) has been long known even in Europe to possess narcotic properties. In Germany and France the seeds are said to be frequently made use of for the perpetration of crime.* In Russia they are added to beer to make it heady and intoxicating—a practice which formerly prevailed also in China, but has been now long forbidden—(GMELIN). In Upper India, the mountain villagers of Sirinagur, and other provinces, employ the same seeds to add to the intoxicating qualities of their common spirituous liquors. In Lower India, the poisoners, who all belong to the caste of Pasie, or dealers in toddy, make use of the seeds of the datura in plying their odious craft. They go about singly or in gangs, haunting the traveller's resting-places, where they drop half a rupee weight of seeds, pounded or whole, into his food. This produces an intoxication of twenty hours' duration, during which he is robbed, and left either to recover or to sink under the stupefying effects of the narcotic. The seed is gathered at any time, place, or age of the plant, without apparent influence upon its efficacy—(DR. HOOKER).†

In this country the seeds are rarely used, except under the direction of a medical man, or when they happen to be swallowed by mistake; and it is singular that when an overdose does happen thus to be taken, especially if it is by a child, the delirium it occasions is often accompanied by spectral illusions more or less wild. A little girl who had

* CHRISTISON *On Poisons*, p. 841.
† *Himalayan Journals*, vol. i. p. 66.

taken a drachm and a half of the seeds became furiously delirious in two hours, saw spectral illusions, and so continued during the night, with intervals of lethargic sleep. Next morning she fell fast asleep, and after some hours awoke quite well—(FOWLER). The symptoms of this case very closely resemble the reputed effects of the seeds of the red datura on the Indians of New Granada. They remind us of the supposed meetings with their ancestors, which, under the influence of the infusion, the Indians esteem themselves privileged to hold.

The narcotic property is not confined to the seeds, but is probably possessed by the whole plant. Alarming narcotic effects have been produced by applying the leaves to an extensive burn, where, from the removal of the skin, the ingredients of the leaf were capable of being absorbed into the system of the patient. In this country the dried leaves and plant are frequently smoked by persons affected with certain forms of spasmodic asthma. For this use they are sometimes made up into the form of cigars, and sold by the druggists for smoking in the same way as tobacco. The smoke is generally swallowed, but few persons, I believe, attempt to use it, except by the direction of a medical adviser.

All the species of thorn-apple, so far as they have hitherto been examined, contain a solid, white, crystalline, poisonous compound, to which the name of daturin has been given. The taste of this substance is at first bitterish, it then becomes acrid, and recalls the taste of tobacco. When taken internally, it strongly dilates the pupil, and in its general action upon the system very much resembles the poisonous principle contained in the well-known common henbane (*Hyoscyamus niger*). It is to the action of this ingredient that the singular effects produced by the seeds, as above described, are believed to be chiefly due.

But when the thorn-apple, leaf and stem, are smoked, an empyreumatic oil is produced, similar to that which is yielded by tobacco leaves when burning in the pipe of the smoker.* Like that of tobacco, also, this empyreumatic oil is very poisonous. The narcotic, soothing, and spasm-stilling effects of the smoke of the thorn-apple, are partly due to the presence of the vapours of this oil. The poisonous daturin of the stramonium leaf may also rise in vapour and mingle with the smoke, as the poisonous nicotin does with the smoke of burning tobacco (p. 316); but this has not as yet been tested by experiment. If so, then, as in the case of tobacco, the full effect experienced by smoking the datura is made up of the joint influence of the mixed vapours of the daturin and of the empyreumatic oil which the smoke contains. The presence of these powerfully narcotic and poisonous principles explains why, as experience has proved, the smoking of the thorn-apple is by no means unattended with danger. The custom of swallowing the smoke causes more of the poisonous ingredients to be absorbed into the system than is usually the case in the smoking of tobacco.

XIII. The Siberian or intoxicating fungus (*Amanita muscaria*) is to the native of Kamtschatka what opium and hemp are to the eastern Asiatics, coca to the Peruvian, and tobacco to the European and North American races. The natural craving for narcotic indulgences has in Siberia found its gratification in a humble toadstool.

This fungus has a close resemblance to some of the edible fungi, and is not unlike our common mushroom (fig. 74). It grows very abundantly in some parts of Kamtschatka, and hence its use in that country. It is either collected during the hot months, and hung up to dry in the air, or it is left in the ground to ripen and dry, and is afterwards

* See the chapter on Tobacco.

gathered. The latter are more narcotic than those which are artificially dried.

When steeped in the expressed juice of the native whortleberry (*Vaccinium uliginosum*), this fungus imparts to it the intoxicating properties of strong wine. Eaten fresh in soups and sauces, it exhibits a less powerful intoxicating quality. But the most common way of using it is to roll it up like a bolus, and to swallow it whole without chewing. If chewed, it is said to disorder the stomach.

Fig. 74.

Amanita Muscaria—Siberian or Intoxicating Fungus.

One large or two small fungi are a common dose to produce a pleasant intoxication for a whole day. If water be drank after it, the narcotic action is increased. The desired effect comes on in the course of an hour or two after the dose is taken. Cheerfulness is first produced, then the face becomes flushed, giddiness and drunkenness follow in the same way as from wine or spirits, involuntary words and actions succeed, and sometimes the final effect is an entire loss of consciousness. In some it provokes to remarkable activity, and stimulates to bodily exertion. In too large doses it induces violent spasms. Upon some individuals it produces effects which are very ludicrous. A talkative person cannot keep silence or secrets. One fond of music is perpetually singing; and if a person under its influence wishes to step over a straw or small stick, he takes a stride or a jump sufficient to clear the trunk of a tree.

The haschisch produces similar erroneous impressions as to size and distance as the one last mentioned. And it is

singular that the erroneous perceptions to which these drugs give rise temporarily—and in the case of haschisch, with a half consciousness of their deceptive character—exist permanently in many lunatics. The reader may also have met with descriptions of old women who were proved to be witches by their being unable to step over a straw!

But the most singular effect of the amanita is the property it imparts to the fluid excretions. It has been known from time immemorial to the inhabitants of Siberia that the fungus gives to the urine an intoxicating quality. This continues for a considerable time after taking it, so that a man who is moderately intoxicated the one day, and has slept himself sober by the next morning, will, by drinking—as is the custom—a tea-cup of his own urine, become more completely intoxicated than before. It is not uncommon, therefore, for confirmed drunkards in that country to preserve their urine as a precious liquor in case of a scarcity of the fungus. This intoxicating property of the fluid is capable of being propagated, so to speak; for every one who partakes of it is similarly affected. Dr. Langsdorff says, that if a second person takes the urine of the first, a third that of the second, and so on, the intoxication may be propagated through five individuals. Thus, with a very few amanitæ, a party of drunkards may keep up their debauch for a week.

We have already seen that morphia, the active principle of opium, passes through the body into the milk and other liquid excretions. The same is the case also with the active principles of cinchona bark, of hemlock, of belladonna, aconite, &c. The Siberian fungus no doubt contains, like most of these, a strongly poisonous narcotic principle. This narcotic ingredient, however, has never been obtained in a separate state, as no chemical investigation of this species of fungus has ever yet been made. We can only judge from

analogy, therefore, as to the nature of the active substance it contains.

We have no experience as yet in this part of Europe of any effects so remarkable as these being produced by any species of fungus. The qualities of this class of plants seem to vary with the climate in which they are grown; but it is probable that some of our poisonous fungi, when tried in the same way, will be found to possess properties analogous to those of the amanita of Siberia. This is rendered more likely by the fact that our common puff-ball, the Lycoperdon proteus, which is not poisonous, emits fumes when burned which possess narcotic properties in a high degree.

It has long been observed, indeed, that poisonous fungi in general, when eaten, produce narcotic among their other effects. It has also been popularly known in this country that the smoke of the burning puff-ball, though in itself wholesome and eatable, has the property of stupefying bees, and it has frequently been used for that purpose when a hive was to be robbed. But it has recently been tried upon higher orders of animals, and similar effects have been found to be produced upon them also. When the fumes of the burning fungus are slowly inhaled, all the ordinary symptoms of intoxication gradually appear. These are followed first by drowsiness, and then by perfect insensibility to pain, like that which follows the use of chloroform; and if the inhalation be continued, this is succeeded by convulsions, occasionally by vomiting, and after some time by death. While recovering from its action, an animal is sometimes perfectly conscious, while it is still insensible to pain.*

The chemistry of this tribe of plants is still very obscure. Two active principles, however, have been recognised in such of the fungi as are possessed of poisonous properties. When distilled with water, they yield a volatile acrid principle

* *Medical Times*, June 11, 1853, and *Chemist*, July 1853.

which has been little examined; and when extracted by water and alcohol, a brown solid substance is obtained, to which—on the supposition that it is the active principle of the genus Amanita—the name of amanitin has been given. But neither the chemical relations nor the specific action of these substances on the human body have as yet been investigated. It may be to their conjoined influence upon the system that the singular effects of the Siberian fungus are to be ascribed.

The unpoisonous puff-ball has not yet been shown to contain any narcotic ingredient resembling the amanitin of the poisonous species. The narcotic effects produced by its smoke when burning must, therefore, at present, be ascribed to the empyreumatic oil, which, like tobacco and the thorn-apples, it yields when burned. This mingles with the smoke, and along with the smoke is drawn into the lungs and there absorbed.

XIV. The minor Narcotics.—Besides the narcotics already mentioned, which may be regarded as national indulgences, and are used by large bodies of men, there are several which possess so much of a local or historical interest, as to make them not unworthy of a brief consideration. I class these together under the name of Minor Narcotics.

1°. The emetic Holly (*Ilex vomitoria*), is the narcotic of the Indians of Florida. An infusion or decoction of the leaves is drunk before the opening of their councils, and on other important occasions. That their heads may be clear when grave questions are about to be discussed, they are said to fast three whole days, drinking meanwhile the infusion of this plant. This infusion is sometimes spoken of as the black drink, probably from its colour.

In moderate doses it acts upon the kidneys, and in-

creases the perspiration. Taken more largely, it moves the bowels and causes vomiting. Used in the proper manner, it also induces a state of excitement and frenzy, so that among the Seminoles it serves the same purposes as opium does in the East. How it is administered to produce these more purely narcotic effects, I have not found described by any author to whom I have had access.

The chemical history of this plant is quite unknown. As a holly, however, (Ilex), it is botanically related to the plant which yields the Paraguay tea.* It probably contains an active principle, therefore, which has an analogy to the theine of the tea leaf.

2°. THE DEADLY NIGHTSHADE.—The black berries of the deadly nightshade or dwale (*Atropa belladonna*), by their beautiful brightness sometimes tempt the young to eat them by mistake. They are powerfully narcotic, and among their earliest symptoms induce the appearance of the most besotted drunkenness. The dried leaves, or an infusion of the leaves, acts in a similar manner. Even a small dose causes an extravagant delirium, which is usually of an agreeable kind. This is sometimes accompanied by excessive and uncontrollable laughter, sometimes by incessant talking, but occasionally by a complete loss of voice. The state of mind sometimes resembles somnambulism, as in the case of a tailor who for fifteen hours was speechless and insensible to external objects, and yet went through all the operations of his trade with great vivacity, and moved his lips as if in conversation—(CHRISTISON).

This narcotic is never now used among us except as a medicine. It possesses an historical interest, however, from the circumstance, related on the authority of Buchanan the historian, "That the destruction of the Danish army, commanded by Sweno, king of Norway, when he invaded Scot-

* See THE BEVERAGES WE INFUSE.

land, was owing to the intoxicating qualities of the berries of this plant, which the Scots mixed with the drink they were obliged to furnish to the invaders. For while the Danish soldiers lay under its soporific influence, the Scotch fell upon them, and destroyed so many, that there were scarcely sufficient left to carry the king on board of the only ship that returned to Norway."*

3°. Common Henbane.—The roots of black henbane (*Hyoscyamus niger*) are strongly narcotic and inebriating. Three grains of the dried watery extract of this root are about equal to one of opium, but it is not so certain in its effects. I am not aware that it has ever been used as a narcotic indulgence.

4°. The bearded Darnel.—Of the home-grown narcotics, natives of our islands, the bearded darnel (*Lolium temulentum*), fig. 75, commonly called sturdy or ryle, creeps occasionally into our fermented liquors and our bread. This grass grows in many places as an abundant weed in the corn-fields of some of our more slovenly farmers. When ripe, it is cut down and thrashed with the corn among which it grows; and when the grain is afterwards imperfecty cleaned, these seeds remain among it. They have been long known to possess narcotic and singularly intoxicating properties. When malted along with barley, which, when the grain is ill-cleaned, sometimes unintentionally happens, they

Fig. 75.

Lolum temulentum—Bearded Darnel or Ryle.
Scale, an inch to a foot.
Seeds, natural size.

* Morehouse *On Intoxicating Liquors*, p. 104.

impart their intoxicating quality to the beer, and render it unusually and even dangerously heady. When ground up with wheat and made into bread, they produce a similar effect, especially if the bread be eaten hot. Many instances are on record in which effects of this kind, sometimes amusing and sometimes alarming, have been produced by the unintentional consumption of darneled bread or beer.

A recent case occurred on Christmas-day (1853) at Roscrea, in Ireland, where several families, containing not less than thirty persons, were poisoned by eating darnel flour in their whole-meal bread. They were attacked by giddiness, staggering, violent tremors similar to those experienced in the *delirium tremens* produced by intoxicating liquors, impaired vision, coldness of the skin and extremities, partial paralysis, and in some cases vomiting. By the use of emetics and stimulants all were recovered, though greatly prostrated in strength.

The narcotic principle in these seeds has not yet been discovered. When distilled with water they yield a light and a heavy volatile oil; but that the narcotic virtue resides in these oils, has not yet been shown. No volatile alkali, like the nicotin of tobacco (p. 316), has been detected in the water and oils which distil over.

5°. Sweet Gale.—Though now, I believe, out of use in this country, the sweet gale (*Myrica gale*) is another native narcotic, of which the qualities appear to have been familiar to the ancient inhabitants of our islands. All the northern nations are said to have used this plant in former times to give bitterness and apparent strength to their fermented liquors. In Sweden this practice still prevails; and, as far back as 1440, King Christopher of Sweden confirmed an *old* law, which inflicted a fine upon those who collected this plant before the proper season, or from another person's land.*

* Beckwith's *History of Inventions* (Bohn's edition), vol. ii. p. 385.

A tradition prevails in Ireland that the Danes knew how to make beer out of heather; and Boethius has preserved an early Scotch tradition of a similar kind. "In the deserts and moors of Scotland," he says, "there grows an herb named heather, very nutritive to beasts, birds, and especially to bees. In the month of June it produces a flower of purple hue as sweet as honey. Of this flower the Picts made a delicious and wholesome liquor. The manner of making it has perished with their extermination, as they never showed the craft of making it except to their own blood." * It is just possible that the grain of truth contained in this tradition may be, that the Picts *flavoured* their barley-worts with twigs of flowering heather; or that, like other northern nations, they used the narcotic gale which grows among the heather, to give a bitter flavour and a more intoxicating quality to the liquor they made from them.

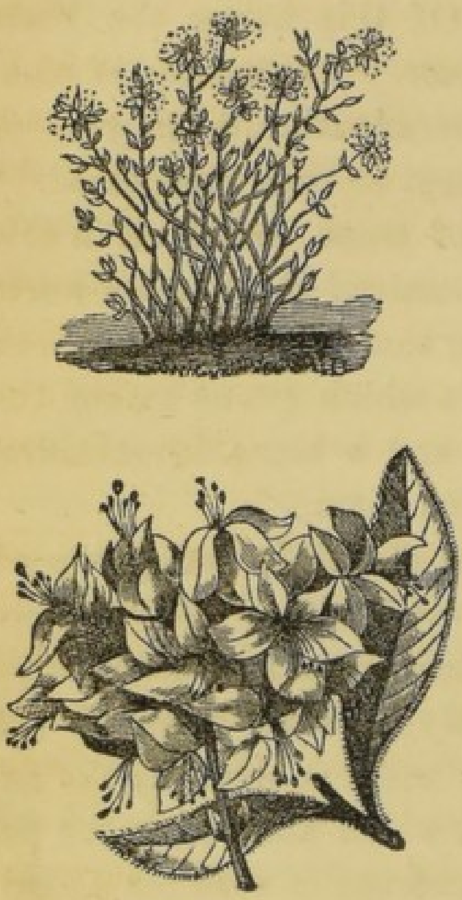
6°. THE RHODODENDRONS form a well-known group of plants in which much narcotic virtue resides. The flowers of the Rhododendron arboreum are eaten as a narcotic by the hill people of India. The rusty-coloured leaves of the Rhododendron campanulatum are used as snuff by the natives of India, and the brown dust which adheres to the petioles of the kalmias and rhododendrons is used for a similar purpose in the United States of North America—(DECANDOLLE). The Rhododendron chrysanthemum, a Siberian bush, is one of the most active of narcotics; but whether it is employed in its native country as a narcotic indulgence, I am not aware.

The *Azalea pontica* (fig. 76), a kindred shrub, which grows abundantly on the borders of the Black Sea, and

* A more precise tradition, current in Teviotdale, has been preserved in LEYDEN'S *Remains*, p. 320, and in Mr. Christmas's very curious book, *The Cradle of the Twin Giants* (vol. ii. p. 198), to which I am indebted for the above extract from Boethius.

hangs out its tempting flowers in the season of honey-making, is said to be the source of the narcotic quality for which the Trebizond honey is famous. The effects of the Euxine honey, according to Pallas, resemble those produced by the bearded darnel, and occur where no true rhododendrons grow. The natives, he adds, are well aware of the poisonous qualities of this azalea. Goats, which browse on its leaves before the pastures become green, feel its influence, and both cattle and sheep are sometimes killed by it. The extraordinary effects which the honey, extracted from the flowers of this azalea produced upon the soldiers of Xenophon,* bear ample testimony to their narcotic qualities.

Fig. 76.



Azalea pontica—The Armenian Azalea.

Scale for plant in flower, with the leaves unexpanded, 1 inch to 5 feet. —Scale for leaves and cluster of flowers, 1 inch to 3 inches.

I might notice many other plants which, though not employed as indulgences, have yet been frequently observed in common life to exhibit narcotic effects. Thus, among heath-plants, the Andromeda polifolia, a small shrub found wild in the bogs of northern Europe and America, is an acrid narcotic, and proves fatal to sheep. Similar properties have been observed, in the United States, in the Andromeda mariana, which is there called kill-lamb, or stagger-bush, because it is supposed to be poisonous to lambs and calves, producing a disease called the staggers.

In the same country the leaves of the Kalmia latifolia

* See The Sweets we extract.

are poisonous to many animals, and are reputed to be narcotic, but their action is feeble. Bigelow states that the flesh of pheasants which have fed on the young shoots is poisonous to man; and cases of severe illness are on record which have been ascribed to this cause alone. This property reminds us of those active ingredients of opium and the Siberian fungus which can pass unchanged through the milk and other liquid excretions of persons who consume them.

About New York and in Long Island the Kalmia angustifolia is believed to kill sheep, and is known by the names of sheep-laurel, sheep-poison, lamb-laurel, and lamb-kill. The flowers of the kalmia exude a sweet honey-like juice, which is said when swallowed to bring on a mental intoxication, both formidable in its symptoms and long in duration—(TORREY). In this it appears closely to resemble the Armenian azalea.

Finally, I may remark that, according to Dr. Bird, the odour of vanilla intoxicates the labourer who gathers it. Even the perfumes of the rose, the pink, and other common sweet-smelling flowers, act on some persons as narcotic poisons—(ORFILA). And the vapours arising from large quantities of saffron are said to produce similar effects—headache, apoplexy, and sometimes death. So much does the constitution of the individual exalt and increase the physiological action of substances which, to the mass of mankind, are not only harmless, but really sources of refined pleasure and enjoyment.

CHAPTER XXII.

THE NARCOTICS WE INDULGE IN.

GENERAL CONSIDERATIONS.

Extended use of narcotic indulgences.—Numbers of men among whom they are consumed.—The use of them to be restrained chiefly by moral means.—Their agricultural and commercial importance.—Total annual production and value.—Their wonderful properties, and interest to the physiologist.—Analogy between diseased states of mind, natural and artificial.—Do all our feelings arise from physical causes?—Special properties of the different narcotics.—Defective state of our knowledge.—National influence of narcotics.—They react upon the constitution and character.—Coincidences in Asiatic and American customs.—Ancient connection between the continents.—General summary.

I CANNOT dismiss the subject of the narcotics of common life, without drawing the attention of my readers to a few of the more interesting considerations which the facts above enumerated suggest to us.

1°. THEIR EXTENDED USE.—And the first reflection which occurs, as we cast a backward glance over the whole subject, is the almost universal use of narcotic indulgences. Siberia has its fungus—Turkey, India, and China, their opium—Persia, India, and Turkey, with all Africa from Morocco to the Cape of Good Hope, and even the Indians of Brazil, have their hemp and haschisch—India, China, and the Eastern Archipelago their betel-nut and betel-pepper—the

Polynesian islands their daily ava—Peru and Bolivia their long-used coca—New Granada and the Himalayas their red and common thorn-apples—Asia and America, and all the world, we may say, their tobacco—the Florida Indians their emetic holly—Northern Europe and America their ledums and sweet gale—the Englishman and German their hop, and the Frenchman his lettuce. No nation so ancient but has had its narcotic soother from the most distant times—none so remote and isolated but has found within its own borders a pain-allayer and narcotic care-dispeller of native growth—none so savage which instinct has not led to seek for, and successfully to employ, this form of physiological indulgence. The craving for such indulgence, and the habit of gratifying it, are little less universal than the desire for and the practice of consuming the necessary materials of our common food.

Thus it may be estimated that the several narcotics are used—

Tobacco,	among	800	millions	of men.
Opium,	"	400	"	"
Hemp,	"	200 to 300	"	"
Betel,	"	100	"	"
Coca,	"	10	"	"

A tendency which is so evidently a part of our general human nature, is not to be suppressed or extinguished by any form of mere physical, fiscal, or statutory restraint. It may sometimes be discouraged or repressed by such means, but even this lesser result is not always attainable. This was proved by the failure of the Spaniards, in their attempts to check the consumption of coca in Peru, of kings and priests to prohibit the spread of smoking in Europe and western Asia, and more recently by the similar failure of the imperial crusade against the use of opium in China. An empire may be overthrown by inconsiderate statutory intermeddling with the natural instincts, the old habits, or the

growing customs of a people, while the instincts and habits themselves are only strengthened and confirmed.

While he laments, therefore, the excesses to which some are led in the use of narcotic substances, the enlightened philanthropist will look to moral rather than to physical or fiscal means as most likely to repress them. The minds of the people who use them must be enlightened. They must be taught to understand what will promote in the greatest degree both their bodily health and their permanent mental comfort. And what will operate more than all, they must be trained up to self-control and self restraint, and to the habit of reining in their natural desires for this or that form of gratification. This, unhappily, mere intellectual culture will never do.

It is, indeed, not less melancholy than it is remarkable, that some of the most striking known instances—of the abuse of opium, for example—have occurred among men of great mental powers, and of more than ordinary intellectual attainments. The reader of the preceding pages will recollect the total paralysis of the bodily and mental energies which befell our great Coleridge while he was a slave to opium; and how the English Opium-eater, as well as many others, found mere intellectual power unable to contend with the excited instinctive cravings of their bodily constitutions, when by long indulgence they had become diseased. Examples like these ought to impress upon every one a Christian sense of his own weakness, and incline him voluntarily to turn aside from the temptations which such men were unable to resist.*

2°. Their agricultural and commercial importance.

* It is comparatively easy to avoid acquiring habits, but it is very difficult to overcome such as are already formed. It was stated the other day at a temperance meeting in London, that of six hundred thousand persons in the United States who had taken the pledge, four hundred and fifty thousand had broken it!

—Then in regard to these narcotic substances, it may be questioned whether many more people are employed in raising the common necessaries of life, than in cultivating and preparing these apparently unnecessary indulgences. Certainly no other crops, except corn, and perhaps cotton, represent more commercial capital, employ more shipping and other means of transport, are the subject of a more extended and unfailing traffic, and the source of greater commercial wealth. The correctness of this may be judged of by the following estimates of the annual produce and value of a few of the narcotics I have mentioned :—

	Produce per acre.	Total produce in lb.	Acres employed.	Value per lb.	Total value in pounds sterling.
Tobacco,	800 lb.	4,480,000,000	5,600,000	2d.	£37,000,000
Opium,	20 "	20,000,000	1,000,000	20s.	20,000,000
The Hop,	660 "	80,000,000	120,000	1s.	4,000,000
Coca, . .	800 "	30,000,000	37,000	1s.	1,500,000
		5,610,000,000	6,725,000		£60,500,000

Besides these, there are consumed in the East five hundred millions of pounds of betel, and twenty millions of pounds of catechu and gambir extract.

Of course, all these estimates are to a great extent conjectural, but they are sufficiently near the truth to show how important an influence the narcotic appetite exercises upon the rural labors and commercial intercourse of mankind.

Its influence on domestic economy becomes equally apparent when we consider how large a proportion of the weekly earnings is often among ourselves expended in gratifying this appetite. But in India, where, on an average, not more than sixpence a-head is yearly spent by the whole population in the purchase of clothing,* narcotic indulgences form the second great necessary of common life.

Bombay Gazette.

3°. Their wonderful action upon the system is not less worthy of attention. The baschisch, besides the more usual intoxicating effect by which it makes the patient, like the infatuated lover, see

> "Helen's beauty in a brow of Egypt,"

brings on that remarkable, rare, and inexplicable condition of the living body, which is distinguished by the name of catalepsy. The limbs of the patient may be moved at will by the bystander; but in opposition to the law of gravity, and apparently without an effort on the part of the patient, they remain for an indefinite period in any position in which they may be placed. The thorn-apple calls up spectral illusions before the deceived eye, and enables the forlorn and down-trodden Indian to hold refreshing converse with the spirits of his rich and powerful ancestors. The Siberian fungus gives insensibility to pain, while consciousness still remains, and, in common with the baschisch, it creates the singular delusion that a straw is too formidable an obstacle to be stepped over. The common puff-ball deprives the patient of speech, motion, and sensibility to pain, while he remains alive to all that passes around him. It thus realises, and proves to be possible, that nightmare of our dreams, in which we imagine ourselves stretched on the funeral bier, sensible to the weeping of real, and the secret satisfaction of pretended friends; aware of the last screw being fixed in the coffin, and the last sod clapped down above us in the grave-yard, and are yet unable to move a lip for our own deliverance! And then how melancholy the idiotic laughter produced by the deadly nightshade—so like that which, in rare and mournful cases, is seen on the old and withered features of one who, in the vigour of his manhood, charmed the world by the brilliancy of his genius, or astonished it by the majesty of his intellectual powers! How singular, in

fine, that influence of coculus indicus, which leaves the mind clear and strong after the limbs have become feeble and the gait tottering, as if the whole man were deadly drunk!

In all these effects the physiologist finds matter of most attractive, most interesting, most useful, and yet most profound and mysterious study. By what kind of action upon the system does the active ingredient of hemp produce the diseased condition we call catalepsy; or that of the thorn-apple, the condition in which men see visions and dream dreams; or that of the fungus, the fearful state of the most fearful nightmares; or that of the nightshade, the melancholy drivelling of the long-strained and worn-out intellectual faculties? How interesting such questions, yet how impossible, in the present state of our knowledge, to answer them!

And yet towards the understanding of these remarkable phases of the human mind, chemistry has already brought us far on our way. It has put into our hands distinct chemical substances, by which any one of these states can be produced temporarily, and at will. Is it by the agency of similar substances, formed naturally in the system, that these diseased states of mind are naturally produced? If so, can we artificially, and by chemical means, counteract these, so as either to retain the mind in a sound condition, or to restore it to its natural health?

Can we produce, for example, virtual insanity—imaginary happiness,* imaginary misery, or the most truth-like delusions—by introducing into the stomach, and thence into the blood which is passing through the hair-like blood-vessels of the brain, a quantity of a foreign body too minute to be recognised by ordinary chemical processes; and may not real natural insanity, in any of its forms, be caused by the natural production within the system itself of minute quan-

* "Madness hath imaginary bliss, and most men have no more."—TUPPER.

tities of analogous substances possessing similar virtues? And, if so produced, will our future chemistry teach us to remove the mental disease, by preventing the production of the cause, or by constantly neutralising its effects?

And these are not merely ends to be aimed it. Even now they appear to be not beyond the pale of hope. For what are so like to each other as the natural and artificial states of mental derangement, and how much light do they throw upon each other? A monomaniac, in apparently perfect bodily health, takes the strangest fancies into his brain, and talks of and reasons upon them as if they were real. A person labouring under delirium tremens sees sights which are invisible to others, and speaks of them to his attendant, as real and present. The second-sighted seer, in his gifted moments, receives strange warnings from shadowy ghosts, and with full faith believes in and reveals them. A strong man, under the influence of haschisch, or the Siberian fungus, sees a huge tree in a tiny straw, and persists in his inability to step over it, as if the tree were really there. A child swallows common thorn-apple seeds, and forthwith spectral illusions dance before it, which the child regards as real. A decoction of a similar plant calls up to the presence of the Indian of Peru the spirits of his ancestors; he converses with them; and when the effects of the drug have disappeared, he relates these imaginary conversations to his neighbours, believing them to be real, and, what is stranger still, they are listened to with an equal faith in their reality. An excited, nervously susceptible, or epileptic female sees lights streaming from human graves, and will-o'-the-wisps dancing around the poles of a magnet, or issuing in flickering mistiness from the finger-tops of an operator; she believes and describes them as real, and, like the credulous Indians, hundreds around her believe the odylic* moonshine

* Reicnenbach ascribes these appearances to an imaginary power, which he calls the *Od* force, and hence the term *Odylic* applied to the phenomena themselves.

to be real too. But are the things seen in any one of these cases more true and real than they are in all the rest? Are they not all delusions alike—mere mockeries, which deceive the diseased or drug-affected senses? And if so nearly allied in nature, may they not be so also in cause and in cure? At all events, what interesting chemico-physiological experiments are suggested by these striking analogies!

Some physiologists, reasoning from analogy, go still farther. They ascribe not only these rarer states of mind, but those also which are much more frequent and common, to the direct physiological action of material substances. M. Moreau, for example, guided by his personal experience of the action of the resin of hemp on his own mind, throws out the conjecture, "that every feeling of joy and gladness, even when the cause of it is exclusively moral—that those enjoyments which are least connected with material objects, the most spiritual, the most ideal—may be nothing else but sensations purely physical, developed in the interior of the system, in the same way as those which are produced by means of the haschisch." In so far as relates to our internal consciousness, at least, he adds, "that there is no distinction to be made between these two orders of sensations, in spite of the diversity of causes to which they are due." This conjecture is eminently suggestive of experimental research, but it goes deeper into the connection between mind and matter than any positive knowledge we possess enables us as yet safely to penetrate.

4°. THE SPECIAL PROPERTIES by which they are severally distinguished are also remarkable features of the narcotics I have described. Thus, while tobacco soothes, and, according to some, sets the mind to sleep, opium and hemp stimulate and exalt the mental faculties, giving the feeling and sense of increased intellectual power. In the case of opium, the activity of mind thus produced resembles the activity of

the mind in sleep. It seems as if, all the bodily organs being at rest, the thoughts and images floated over or through the quiescent brain without fatiguing or wasting it, as cloud and sunshine flit over a fair landscape without stirring or physically changing it. With hemp it is otherwise. It occasions hunger along with the mental activity. Prolonged thought in the waking man makes the head smoke, as it were. Like physical exertion, it exhausts the body, and brings on a hunger which can only be stayed by ordinary food. And so the mental activity occasioned by hemp resembles more that of the waking than of the sleeping man. This agrees with another observed difference between the two. Opium lessens the susceptibility to external impressions, while haschisch increases and quickens it in a high degree. The one shuts up the mind, as it were, within itself, while the other throws it open to the most lively influence of every bodily sense. It is also in agreement with all these differences, that the action of opium is interrupted and lessened by disturbance and bodily motion, while that of hemp is diminished by stillness and repose. In this latter quality hemp agrees with ardent spirits.

Coca and opium, again, agree in sustaining the strength, in certain circumstances, in a marvellous manner; yet they differ in two important qualities. The former never induces sleep as opium does, and even when taken in great excess, it moves the bowels, while opium usually makes them torpid and costive. Betel rouses from the effects of opium, as tea does from that of ardent spirits. The Siberian fungus opens and shows the heart as good wine is said to do. Secrets drop out spontaneously under its influence, and either the will or the ability to retain them has for the time gone to sleep.

Such specialties are curious and interesting in themselves; but they are so also in showing that the several nar-

cotic substances act upon the system, and disturb the mind in different ways. They strengthen the probability, therefore, that, by the use of special chemical substances, we may be able hereafter to control the similarly differing mental affections by which natural diseases are so often accompanied.

5°. How defective our knowledge is.—Yet though, from what we do know, we may venture to express such hopes as these, it must have struck the reader of the preceding chapters how very defective our knowledge is, both of the chemical nature and of the physiological action of the narcotics in which we indulge. The field of study which they present is indeed captivating and extensive; but hitherto the materials and opportunities for cultivating it have presented themselves rarely, at intervals, and to few individuals. The growing sense of the importance of chemical physiology to the art of medicine, however, promises, by-and-by to make the value of a higher acquaintance with chemistry more manifest to medical men, and thus to lead a greater number of that profession to qualify themselves for chemico-physiological investigations. As this desirable change takes place, we may expect to see many gaps in our present knowledge gradually filling up.

6°. National influence of narcotics.—We have seen that almost every part of the world grows and consumes its own peculiar narcotic. The use of each of these in the country which produces it seems natural enough. It is consumed, as the national species or variety of grain is, because it is most easily and plentifully obtained. But when different narcotics are equally accessible, why is one selected rather than another? England, for example, drinks much hopped beer, while Scotland and Ireland drink comparatively little. It is, no doubt, owing to some peculiarity in the national character and constitution that the narcotic hop, and proba-

bly also tobacco, are used more largely in the south than in the north of our island—that the German and Swede smoke more than the Frenchman—that opium and haschisch, so loved in the East, have made such slow progress in our European affections. And so the different forms in which the same substance is used are probably, in part at least, constitutional. France, the North of Scotland, Iceland, and Northern Scandinavia, are great consumers of snuff. England, Germany (high and low), Southern Scandinavia, and Russia, prefer to burn their tobacco and inhale its smoke. Snuff is much used also by the African races who live between the Red Sea and the Upper Nile, while the Mograbins are great chewers, and the Turks and Arabs as constant smokers—(WERNE). It may be said that differences such as these are mere matters of taste; but national taste, though sometimes the child of habit, is more frequently the offspring of constitution and bodily temperament.

But does the use of the peculiar narcotic not again react upon the constitution, and gradually change the disposition and temperament? It probably does. The soothers and exciters we indulge in to excess are seen gradually to affect the constitution, and sensibly to modify the temper and constitution of individuals. Let the use of these become general, and similar changes will in time affect the whole people. We cannot tell how far such constitutional alterations may proceed. But it is a problem of interest to the legislator, not less than to the physiologist and psychologist, to ascertain how far and in what direction such changes may go—how much of the actual tastes, habits, and character of existing nations has been created by the prolonged consumption and prevailing forms of the narcotics in daily use—how far tastes and habits have been modified by the changes in these forms which have been adopted within historic times —and what influence their continued use is likely to exer-

cise on the final fortunes of this or that people. The fate of nations has frequently been decided by the slow operation of long-acting causes, unthought of and unestimated by the historian, which, while the name and local home of the people remained the same, had gradually changed their constitution, their character, and their capabilities.

7°. Asiatic and American customs.—In connection with this subject, it is also very striking that so many close coincidences should exist between Asiatic and American customs. Such are the very ancient use of tobacco in China, as well as in Central America—the use of hemp by the natives of Brazil, as well as by those of India and the East—the practice of chewing lime or plant ashes with the coca in Peru, and with the betel in India and China*—the use of the red thorn-apple by the hill Indians of the Andes, and of the common thorn-apple by the hill people on the slopes of the Himalayas. All these coincidences can scarcely be the result of chance; they are evidences rather of ancient intercourse between Asia and America—possibly even of ancient family relationship between their early inhabitants.

We are accustomed to trace analogies among nations by means of alphabets, names of things, forms of speech, modes of writing, religious rites, &c., and from these to infer a family connection or a community of origin. But old habits and peculiar customs of common life, clung to often not only with the fondness of a natural instinct, but with a reverence

* It is a singular circumstance, with which I was not acquainted while writing the chapter on tobacco, that the Mograbins of Northern Africa chew natron (the natron carbonate of soda of the desert bordering countries) with their tobacco; and that the blacks of Gesira make a cold infusion of natron and tobacco, with a mouthful of which they delight to rinse their mouths for a quarter of an hour, and then reject it. Is this custom of chewing soda with tobacco an imitation of the betel and lime used by the Indian traders to the African ports of the Red Sea?—or is the origin of both customs to be found in the abundance of natron about the natron lakes and elsewhere in Northern Africa? In either case, it is equally remarkable that a similar practice should prevail on the Andes of Peru.

inspired by high national antiquity—these are not less important evidences of ancient intercourse. They are also more persistent. They may survive after power, civilisation, language, alphabets, writings, and even old religions, have disappeared. The chewing of coca in Peru has outlived all these. The common-life customs and the bodily features of the people have alone survived.

Philological travellers describe, as the most ancient race among the Mexican mountains, a tribe of Indians speaking a monosyllabic language which bears considerable resemblance to the Chinese. The similarity of customs above described is equally close and striking. And the most cautious ethnologist will scarcely refuse to consider the two kinds of evidence as materially aiding each other, and giving strength to the conclusion to which they both point—that a remote family connection exists between the Indian inhabitants of America and the most ancient populations of Eastern Asia.

8°. General summary.—From all that we know on the subject of the narcotics, we may, I think, extract these general propositions :—

First, That there exists a universal craving in the whole human race for indulgences of a narcotic kind. This is founded in the nature of man.

Second, That this craving assumes in every country a form which is more or less special to that country. It is modified most by climate, less by race, and least, though still very sensibly, by opportunity.

Third, That among every people the form of craving special to the whole undergoes subsidiary modifications among individuals. These are determined by individual constitution first, and next by opportunity. Hence different professions, in consequence of acquired habits and states of body, show the craving in differently modified forms. And

hence, also, the different classes of society, because of their unlike means and opportunities, exhibit similar differences.

Fourth, That differences in physiological action, which are sometimes very slight, separate—

a. The more dreaded from the less dreaded narcotics—opium and hemp from tobacco and the hop.

b. The narcotics from the fermented liquors—opium from alcohol.

c. The milder from the fiercer alcoholic drinks—the beers and wines from the brandies.

d. The mildest fermented drinks from the beverages we infuse—the beers from the teas and coffees.

All these indulgences shade into each other, often by almost imperceptible degrees, and our constitutions, in favourable circumstances, insensibly adapt themselves to all. How much, therefore, ought we to be on our guard against their insidious attractions.

Lastly, I may remark that, with the enticing descriptions before him, which the history of these narcotics presents, we cannot wonder that man, whose constant search on earth is after happiness, and who, too often disappointed here, hopes and longs, and strives to fit himself for happiness hereafter—we cannot wonder that he should at times be caught by the tinselly glare of this corporeal felicity, and should yield himself to habits which, though exquisitely delightful at first, lead him finally both to torture of body and to misery of mind ;—that, debilitated by the excesses to which it provokes, he should sink more and more under the influence of a mere drug, and become at last a slave to its tempting seductions. We are indeed feeble creatures, and small in bodily strength, when a grain of haschisch can conquer, or a few drops of laudanum lay us prostrate ; but how much weaker in mind, when, knowing the evils they lead us to, we are unable to resist the fascinating temptations of these insidious drugs !

CHAPTER XXIII.

THE POISONS WE SELECT.

The consumption of white arsenic.—Action of arsenic upon the system.—Practice of using it in Styria.—Its effects in improving the complexion and removing breathlessness.—Quantity taken.—Length of time it may be used with impunity.—Illness produced by discontinuing it.—Its effects upon horses.—Its chemico-physiological action in producing these effects.—Ancient love-philtres and charms.—Incredible things formerly believed.—The eating of clay.—Practice in Guinea, in the West Indies, in Java, in the Himalayas.—Use of bread-meal and mountain-meal in Sweden, Finland, and North Germany.—The Otomacs in South America.—Humboldt's account.—Does clay support life?—Eaten by the Indians of Bolivia and Peru.—Its physiological action.—Our ignorance still great.

I SHOULD omit from this outline of the chemistry of common life some of the most remarkable features it presents, were I not to add to the preceding chapters on narcotic indulgences a brief notice of two other forms of indulgence not less wonderful and extraordinary. These are, the habitual consumption of arsenic, and the practice of eating clay.

I. THE CONSUMPTION OF WHITE ARSENIC.—Arsenic, as we commonly call it—the white arsenic of the shops and the arsenious acid of the chemist—is well known as a violent poison. Swallowed in large doses, it is what medical writers call an irritant poison. In very minute doses it is known to professional men as a tonic and alterative, and is sometimes administered with a view to these effects. It is

remarkable also for exercising a peculiar influence upon the skin, and is therefore occasionally employed in cutaneous diseases. The use of arsenic, however, is unfrequent among regularly educated practitioners, and it is never, I believe, used as a household medicine by the people.

In some parts of Lower Austria, however, in Styria, and especially in the hilly country towards Hungary, there prevails among the common people an extraordinary custom of eating arsenic. During the smelting of lead, copper, and other ores, white arsenic flies off in fumes, and condenses in the solid form in the long chimneys which are usually attached to the smelting furnaces. From these chimneys, in the mining regions, the arsenic is obtained, and is sold to the people by itinerant pedlars and herbalists. It is known by the name of *Hidri*,* and the practice of using it is of considerable antiquity. By many it is swallowed daily throughout a long life, and the custom is even handed down hereditarily from father to son.

Arsenic is thus consumed chiefly for two purposes—*First*, To give plumpness to the figure, cleanness and softness to the skin, and beauty and freshness to the complexicn. *Second*, To improve the breathing and give longness of wind, so that steep and continuous heights may be climbed without difficulty and exhaustion of breath. Both these results are described as following almost invariably from the prolonged use of arsenic either by man or by animals.

For the former purpose young peasants, both male and female, have recourse to it, with the view of adding to their charms in the eyes of each other; and it is remarkable to see how wonderfully well they attain their object, for those young persons who adopt the practice are generally remarkable for clear and blooming complexions, for full rounded figures, and for a healthy appearance. Dr. Von Tschudi

* A corruption of *Hutter-rauch*, smelt-house smoke.

gives the following case as having occurred in his own medical practice: "A healthy, but pale and thin milkmaid, residing in the parish of H——, had a lover whom she wished to attach to her by a more agreeable exterior; she, therefore, had recourse to the well-known beautifier, and took arsenic several times a-week. The desired effect was not long in showing itself; for in a few months she became stout, rosy-cheeked, and all that her lover could desire. In order, however, to increase the effect, she incautiously increased the doses of arsenic, and fell a victim to her vanity. She died poisoned, a very painful death." The number of such fatal cases, especially among young persons, is described as by no means inconsiderable.

For the second purpose—that of rendering the breathing easier when going uphill—a small fragment of arsenic is put into the mouth, and allowed to dissolve, which it does very slowly. The effect is described as astonishing. Heights are easily and rapidly ascended, which could not otherwise be surmounted without great difficulty of breathing.

The quantity of arsenic taken by those who are beginning the practice varies with the age, sex, and constitution, but it never exceeds half a grain. This dose is taken two or three times a-week, in the morning fasting, till the patient becomes accustomed to it. The dose is then cautiously increased as the quantity previously taken diminishes in its effect. "The peasant R——," says Dr. Von Tschudi, "a hale man of sixty, who enjoys capital health at present, takes for every dose a piece about two grains in weight. For the last forty years he has continued the habit, which he inherited from his father, and which he will transmit to his children."

No symptoms of illness or of chronic poisoning are observable in any of these arsenic-eaters, when the dose is carefully adapted to the constitution and habit of body of

the person using it. But if from want of material, or any other cause, the arsenic be left off for a time, symptoms of disease occur which resemble those of slight arsenical poisoning. Especially a great feeling of discomfort arises, great indifference to every thing around, anxiety about their own persons, deranged digestion, loss of appetite, feeling of overloading in the stomach, increased flow of saliva, burning from the stomach up to the throat, spasms in the throat, pains in the bowels, constipation, and especially oppression in the breathing. From these symptoms there is only one speedy mode of relief, namely, an immediate return to arsenic-eating.

This custom never amounts to a passion like that of opium-eating in the East, betel-chewing in India, or coca-chewing among the Peruvians. It is not, like opium or hemp, a source of intense pleasure, the craving for which cannot be resisted; but, the habit once acquired, the fear of pain compels its continuance. The use of arsenic has become a necessity of life.

Upon animals the effects are similar to those which are produced upon man. It fattens and plumps out the horse, gives it a bright and glossy skin, and an appearance of high health and condition. Hence this use of arsenic is very common in Vienna, especially among gentlemen's grooms and coachmen. They either sprinkle a pinch of it among the oats, or they tie a piece as big as a pea in linen, and fasten it to the bit when the bridle is put into the horse's mouth. There it is gradually dissolved by the saliva, and swallowed. The sleek, round, glossy appearance of many of the first-rate coach horses, and especially the foaming at the mouth, which is so much admired, is owing to the arsenic they get. In mountainous districts also, where horses have to drag heavy burdens up steep places, the drivers often put a dose of arsenic into the last portion of food they give them. This

practice may be continued for years, with horses as with men, without the least injury; but if a horse which is used to it comes into the possession of one who does not give arsenic, it loses flesh and spirits, and its strength sensibly diminishes. In this state the most nutritious food is unable to restore the animal to its former appearance; but a few pinches of arsenic speedily bring it round again.*

Though very different in its nature from the narcotic substances described in the preceding chapters, yet the effects which result from the use of arsenic resemble some of those which are produced by the use of narcotics. Thus arsenic resembles coca in making the food appear to go farther, or to have more effect in feeding or fattening the body; and, like coca, it gives the remarkable power of climbing hills without breathlessness. Farther, it resembles both coca and opium, and especially the latter, in creating a diseased and uncomfortable state of body, when the practice of eating it is interrupted, and in thus becoming through long use a necessity of life.

The chemico-physiological action of arsenic in producing these curious effects has not as yet been experimentally investigated. The peculiar influence exercised by arsenic upon the skin is the cause of the improved appearance in the complexion of the human subject, and in the outer coat of the horse; but the physiological nature of this influence, and how arsenic comes to exercise it, we cannot even conjecture.

Among other ways in which it acts chemically upon the system, experiment will probably show that it lessens the natural waste of the body, and especially that it diminishes the quantity of carbonic acid discharged from the lungs in a given time. The consequence of this action upon the lungs

* *Medecinische Wochenschrift* of Vienna, 11th October 1851, quoted in the "British Journal of Homœopathy." The facts, I believe, are undisputed.

will be—*first*, that less oxygen will require to be inhaled, and hence a greater ease in breathing under all circumstances, but which will be especially perceived in climbing hills; *second*, that the fat of the food which would otherwise be used up in supplying carbonic acid to be given off by the lungs, will be deposited instead in the cellular tissue beneath the skin, and thus will feed, plump out, and render fat and fleshy the animal which eats it.

Still, how arsenic produces or can produce such a lessening of the carbonic acid formed within the body, and discharged by the lungs, is quite inexplicable: it is another of the chemico-physiological mysteries of which common life, both animal and vegetable, is so full.

The perusal of the above facts regarding arsenic—taken in connection with what has been previously stated as to the effects of the resin of hemp—recalls to our mind the dreamy recollections of what we have been accustomed to consider as the fabulous fancies of easy and credulous times. Love-philtres, charms, and potions start up again as real things beneath the light of advancing science. From the influence of hemp and arsenic no heart seems secure—by their assistance no affection unattainable. The wise woman, whom the charmless female of the East consults, administers to the desired one a philtre of haschisch, which deceives his imagination—cheats him into the belief that charms exist, and attractive beauty, where there are none, and defrauds him, as it were, of a love which, with the truth before him, he would never have yielded. She acts directly upon his brain with her hempen potion, leaving the unlovely object he is to admire really as unlovely as before.

But the Styrian peasant-girl, stirred by an unconsciously growing attachment—confiding scarcely to herself her secret feelings, and taking counsel of her inherited wisdom only—really adds, by the use of hidri, to the natural graces of her

filling and rounding form, paints with brighter hues her blushing cheeks and tempting lips, and imparts a new and winning lustre to her sparkling eye. Every one sees and admires the reality of her growing beauty: the young men sound her praises, and become suppliants for her favour. She triumphs over the affections of all, and compels the chosen one to her feet.

Thus even cruel arsenic, so often the minister of crime and the parent of sorrow, bears a blessed jewel in its forehead, and, as a love-awakener, becomes at times the harbinger of happiness, the soother of ardent longings, the bestower of contentment and peace!

It is probable that the use of these and many other love-potions has been known to the initiated from very early times—now given to the female to enhance her real charms—now administered to the lords of the creation, to add imaginary beauties to the unattractive. And out of this use must often have sprung fatal results,—to the female, as is now sometimes the case in Styria, from the incautious use of the poisonous arsenic; to the male, as happens daily in the East from the maddening effects of the fiery hemp. They must also have given birth to many hidden crimes which only romance now collects and preserves—the ignorance of the learned having long ago pronounced them unworthy of belief.*

* The many real follies which the history of love-potions contains, in a great measure justify such incredulity. Such, for example, are the absurdities mentioned in the following passage: "To be brief,—to as great effect does the virgin parchment serve, as doth the amorous potion or love-drink, of which, as the saying is, Lucretius the poet died; and Caligula the emperor became with such another to be enraged, and, in a sort, distracted, and out of his wits; his wife Cæsonia having given him such a kind of drink, who, for that cause, was also slain by the soldiers that had before killed her husband, as Josephus reporteth. And more than so, this seemeth to be that Hippomanes, which is apt to stir and procure love, no less than the true Hippomanes plucked from the forehead of a horse colt, whereof Virgil, Propertius, and other poets speak much; or that Hippomanes which, as Theocritus reporteth, was planted amongst the Arcadians; or that fish called Remora, which, as Aristotle saith,

II. The eating of clay.—Among the extraordinary passions for eating uncommon things is to be reckoned that which some tribes of people exhibit for eating earth or clay. Though not so directly or immediately poisonous as arsenic, the swallowing of clay, with our ordinary European constitutions and habits, could scarcely be otherwise than injurious to the bodily health; but in Western Africa the negroes of Guinea have been long known to eat a yellowish earth, there called *caouac*, the flavour or taste of which is very agreeable to them, and which is said to cause them no inconvenience. Some addict themselves so excessively to the use of it, that it becomes to them a kind of necessity of their lives—as arsenic does to the Styrian peasant, or opium to the Theriaki—and no punishment is sufficient to restrain them from the practice of consuming it.

When the Guinea negroes used in former times to be carried as slaves to the West India Islands, they were observed to continue the custom of eating clay; but the *caouac* of the American islands, or the substance which the poor negroes attempted in their new homes to substitute for the African earth, was found to injure the health of the slaves who ate it. The practice, therefore, was long ago forbidden, and has probably now died out in our West India colonies. In Martinique, a species of red earth or yellowish tufa was still secretly sold in the markets in 1751; but the use of it has probably ceased in the French colonies also. Whether the custom still exists in Cuba and Brazil, where the slave-trade is not yet entirely extinguished, we do not know. Recent information upon the subject is wanting

was good for love, and for happy success in suits of law; or the bird called Sippe, spoken of by the same Aristotle; or the lizard, bruised and infused in wine, according as Theocritus prescribeth; or the hair which is found in the end of a wolf's tail; or else the bone of a frog or a toad, which hath been cast into a nest of ants, by whom the flesh thereof hath been gnawed away, as Pliny affirmeth."—*The Cradle of the Twin Giants, Science and History*. By Henry Christmas, M. A. Vol. ii. p. 261.

not only from these countries, but also from the western coast of Africa.

In Eastern Asia a similar practice prevails in various places. In the island of Java, between Sourabaya and Samarang, Labillardière saw small square reddish cakes of earth sold in the villages for the purpose of being eaten. These have been found by Ehrenberg to consist for the most part of the remains of microscopic animals and plants, which had lived and been deposited in fresh water. In Runjeet valley, in the Sikkim Himalaya, a red clay occurs, which the natives chew as a cure for the goitre—(HOOKER.)* The chemical nature of this Indian clay has not been examined.

In Northern Europe, especially in the remote northern parts of Sweden, a kind of earth known by the name of bread-meal is consumed in hundreds of cart-loads, it is said, every year. In Finland a similar earth is commonly mixed with the bread. In both these cases the earth employed consists for the most part of the empty shells of minute infusorial animalcules, in which there cannot exist any ordinary nourishment. In north Germany also, on various occasions where famine or necessity urged it—as in long-protracted sieges of fortified places—a similar substance, under the name of mountain-meal, has been used as a means of staying hunger.

In Southern America, likewise, the eating of clay prevails among the native Indians on the banks of the Orinoco, and on the mountains of Bolivia and Peru. The most precise and detailed accounts we possess on this subject, in regard to the Indians of the Orinoco, is given by Humboldt. In north latitude 7° 8′, and west longitude 67° 18′, he met with the tribe of the Otomacs, of which he writes as follows :—

"The earth which the Otomacs eat is an unctuous,

* *Himalayan Journals*, vol. i. p. 145.

almost tasteless clay—true potter's earth—which has a yellowish-grey colour, in consequence of a slight admixture of oxide of iron. They select it with great care, and seek it in certain banks on the shores of the Orinoco and Meta. They distinguish the flavour of one kind of earth from that of another, all kinds of clay not being alike acceptable to their palate They knead this earth into balls measuring from four to six inches in diameter, and bake them before a slow fire, until the outer surface assumes a reddish colour. Before they are eaten the balls are again moistened. These Indians are mostly wild uncivilized men, who abhor all tillage. There is a proverb current among the most distant tribes living on the Orinoco, when they wish to speak of any thing very unclean—'so dirty that the Otomacs eat it.'

"As long as the waters of the Orinoco and the Meta are low, the people live on fish and turtles. They kill the former with arrows, shooting the fish, as they rise to the surface of the water, with a skill and dexterity that has frequently excited my admiration. At the periodical swelling of the rivers the fishing is stopped, for it is as difficult to fish in deep river water as in the deep sea. It is during these intervals, which last from two to three months, that the Otomacs are observed to devour an enormous quantity of earth. We found in their huts considerable stores of clay balls piled up in pyramidal heaps. An Indian will consume from three-quarters of a pound to a pound and a quarter of this food daily, as we were assured by the intelligent monk, Fray Ramon Bueno, a native of Madrid, who had lived among these Indians for a period of twelve years. According to the testimony of the Otomacs themselves, this earth constitutes their main support in the rainy season. They eat, however, in addition, when they can procure them, lizards, several species of small fish, and the roots of a fern. But they are so partial to clay, that even in the dry season, when

there is an abundance of fish, they still partake of some of their earth-balls, by way of a *bonne bouche* after their regular meals.

"These people are of a dark copper-brown colour, have unpleasant Tartar-like features, and are stout, but not protuberant. The Franciscan, who had lived amongst them as a missionary, assured us that he had observed no difference in the condition and well-being of the Otomacs during the periods in which they lived on this clay. The simple facts are therefore as follows: The Indians undoubtedly consume large quantities of clay without injuring their health; they regard this earth as a nutritious article of food—that is to say, they feel that it will satisfy their hunger for a long time. This property they ascribe exclusively to the clay, and not to the other articles of food which they contrive to procure from time to time in addition to it. If an Otomac be asked what are his winter provisions—the term in the torrid parts of South America implying the rainy season—he will point to the heaps of clay in his hut."*

Although the mouths of the Orinoco are at no great distance either from the West India Islands or from the colonies of Guiana, this custom of the Otomacs differs so much from that of the Guinea negroes that we can scarcely believe it to have been borrowed by them from any runaway negro slaves. It is more probably of old date, if not indigenous to the country.

This is rendered more likely by the fact that a similar practice prevails towards the south-west, in the hill-country of Bolivia and Peru. In describing the various articles he saw exposed for sale in the provision-markets of La Paz, on the eastern Cordillera, Dr. Weddell says: "Lastly, the mineral kingdom contributes its share to the Bolivian markets, and it is sufficient to see the important place which this con-

* Humboldt's *Views of Nature*, pp. 143, 144. Bohn's edition.

tingent occupies on the stalls of La Paz, to be satisfied that the part it plays is deserving of much attention. The substance I allude to is a species of grey-coloured clay, very unctuous to the touch, and distinguished by the name of *pahsa*. The Indians, who are the only consumers of it, commonly eat it with the bitter potato of the country, *Papa amargas*. They allow it to steep for a certain time in water, so as to make a kind of soup or gruel, and season it with a little salt. It has the taste of ordinary clay.

"At Chiquisaca, the capital of the State, as I was informed, small pots are made of an earth called *chaco*, similar to the pahsa of La Paz. These are eaten like chocolate. I was told of a señorita who had killed herself by an extreme fondness for these little pots, but it appears that the moderate use of pahsa is followed by no bad effects. The chemical examination of these substances shows that they cannot, in any way, contribute to the nourishment of the body."*

The eating of certain varieties of earth or clay may therefore, be regarded as a very extended practice among the native inhabitants of the tropical regions of the globe. It stays or allays hunger, in some unknown way, stilling probably the pain and craving to which hunger gives rise. It enables the body to be sustained in comparative strength with smaller supplies of ordinary food than are usually necessary, and it can be eaten in moderate quantities even for a length of time without any sensible evil consequences. A fondness even is often acquired for it, so that it comes at last to be regarded and eaten as a dainty.

In what way such effects can be produced by such sub stances we do not understand. That they *are* produced is testified by so many witnesses that we cannot refuse our belief. Yet they appear so contrary to all our common experience as to the dependence of animal life and strength on

* WEDDELL, *Voyage dans le nord de la Bolivie*, p. 161.

what we usually call the necessaries of life, that we naturally hesitate to believe what we are so unable to explain. The more we consider, however, the statements contained in this and the preceding chapters regarding the beverages, the narcotics, and the poisons, the more we shall be satisfied of the imperfect state of our knowledge as to what concerns the maintenance and comfort of our lives. We are especially ignorant still of the conditions as to quantity and forms of food under which man will *refuse to live* in the varied circumstances of climate, habit, and constitution to which he is subject. But this will come under our notice again, in a succeeding chapter, when we consider WHAT, HOW, AND WHY WE DIGEST.

CHAPTER XXIV.

THE ODOURS WE ENJOY.

VOLATILE OILS AND FRAGRANT RESINS.

Vegetable odours.—The volatile oils; how extracted.—Quantity yielded by plants.—The otto of roses; how collected.—The oils exist in different parts of plants.—Simple and mixed perfumes.—Analogy between odours and sweet sounds.—Odours may resemble and blend with each other.—Extraction of oils by maceration.—Quantity of volatile oils imported.—Composition of oils of lemons, oranges, &c.—Isomeric oils.—Oils containing oxygen.—Volatile oils of almonds and cinnamon.—Artificial essences.—Oil of spiræa; can be prepared by art.—Manufactured substitutes for oil of bitter almonds.—Nitro-benzol, or essence de Mirbane.—Nitro-benzyl another substitute.—The camphors.—Chinese and Borneo camphors.—Balsams of Peru and Tolu.—The odoriferous resins; why they become fragrant on red-hot charcoal; their use as incense.—Vanilla, its fragrance, and analogy to the balsams.—The Tonka bean; coumarin, the odoriferous principle of this bean.—The same principle in vernal grass, melliot, and other plants.—Gives fragrance to hay, and probably produces hay fever.

Among the appliances of common life by which the comfort of man in a civilized state is very materially affected, are the odours he enjoys and the smells he dislikes. Upon the origin, nature, mutual relations, and physiological action of these, modern chemistry has thrown much light. I shall, therefore, in this place briefly illustrate their chemical history.

The odours we enjoy are nearly all derived, either directly or indirectly, from the vegetable kingdom. Among scents in common use, musk, civet, and ambergris, are the only ones which owe their origin to animal life; while with pleasant smells of a purely mineral origin we are as yet altogether unacquainted.

I. VEGETABLE ODOURS.—The odoriferous substances yielded by plants are of three kinds—the volatile oils, such as the oils of lemons and lavender—the camphors, balsams, and sweet-smelling resins—and the volatile ethers, such as those which give their agreeable bouquet to different kinds of wine.

1°. THE VOLATILE OILS.—When the parts of odoriferous plants are distilled with water, an oil passes over along with the steam, and floats on the surface of the water, which condenses in the receiver. This volatile oil usually exhibits in a high degree the peculiar smell, and often also the taste of the plant from which it is extracted. In this way are obtained the oils of roses, lavender, lemons, oranges, orange flowers, cinnamon, peppermint, and many others, which in smell and taste remind us at once of the plants from which they have been distilled.

The greater part of the oil usually floats on the surface of the water which distils over along with it. But this water always retains a small portion of the oil in solution, and from this oil it acquires both smell and taste. Thus rose water, lavender-water, peppermint-water, &c., are simply waters impregnated with a minute quantity of the oil from which they severally derive their names. The water distilled from myrtle flowers forms that very agreeable perfume known in France by the name of *eau d'ange.*

The quantity of oil yielded by some plants is so small, that the water which distils over along with it retains it all in

solution. In such cases the oil is difficult to obtain, and is in consequence very expensive. Roses are among the flowers which yield their oil in such minute quantities, and hence the high price of the pure attar of roses. The rose-gardens at Ghazepore are fields in which small rose-bushes are planted in rows. In the morning they are red with blossoms, but these are all gathered before mid-day, and their leaves distilled in clay stills, with twice their weight of water. The water which comes over is placed in open vessels, covered with a moist muslin cloth to keep out dust and flies, and exposed all night to the cool air or to artificial cold—as we set out milk to throw up its cream. In the morning, a thin film of oil has collected on the top, which is swept off with a feather, and carefully transferred to a small phial. This is repeated, night after night, till nearly the whole of the oil is separated from the water. Twenty thousand roses are required to yield a rupee weight of oil, which sells for £10 sterling—(Hooker).* Pure attar of roses is therefore rarely to be met with. That which is sold in the Indian bazaars is adulterated with sandal-wood oil, or diluted with sweet salad oils. What we obtain in Europe is generally still more diluted, as the price we usually give for it sufficiently shows.

The odoriferous principle is not always diffused uniformly over the whole plant. In some, as in mint and thyme, it resides in the leaves and stem; in others, as in the cinnamon tree, it is in the bark; in others, as in the sandal and cedar trees, it is in the wood; in others, like the rose, the lily, the violet, and the jasmin,† it is in the leaves of the flower. In many, like the Tonquin bean, the anise, and the

* The weight of a rupee is something less than 176 grains. Others say that a thousand roses yield less than two grains of oil. Of course the quantity must vary very much as the scent of the rose is greater or less.

† Pure oil of jasmin is almost as rare and dear as pure attar of roses. At the Great Exhibition of 1851, six ounces of it were exhibited, the price of which was nine pounds an ounce.

carraway, it is in the seed; while in some, like ginger, the iris, and the vitivert, it is in the root. It sometimes even happens that distinctly different scents are extracted from different parts of the same plant. Thus the orange tree, from its leaves, yields a perfume called *petit grain*—from its flowers, another called *neroli*—and from the rind of its fruit the essential oil of oranges, called also essence of Portugal.

These volatile oils and scented waters are used as perfumes for the toilet, to flavour the *bonbons* of the confectioner, or for giving an agreeable relish to the finer dishes of the cook. The oils of roses, lavender, orange flowers, &c., are sold only for toilet use, and for scenting the preparations of the perfumer; while those of lemons, peppermint, cinnamon, cloves, ginger, &c., are employed almost solely by the confectioner and the cook.

Every pure volatile oil is a definite chemical compound, possessed of properties which are constant and peculiar to itself. Among other properties, it possesses an odour more or less pronounced, by which it can in most cases readily be recognised. Upon this odour, when agreeable, its value and estimation depend; and the quality of the odour determines the purpose, in perfumery or otherwise, for which it is employed. The pure and unmixed odours of such single oils are often highly esteemed, and by some persons preferred to all other scents. But in preparing delicate perfumes it is seldom that a single oil, or the parts of one plant only, are employed for the purpose. The art of the perfumer is shown by the skill with which he combines together the odoriferous principles of various flowers, or mingles together many volatile essences, so as to produce a more grateful scent than any single plant can be made to yield. In this way the *huille de mille fleurs* (oil of a thousand flowers) professes to be made; and the secret recipe for the popular *Eau de*

Cologne—called the perfection of perfumery—depends for its excellency on the same principle.*

Odours resemble very much the notes of a musical instrument. Some of them blend easily and naturally with each other, producing a harmonious impression, as it were, on the sense of smell. Heliotrope, vanilla, orange blossoms, and the almond blend together in this way, and produce different degrees of a nearly similar effect. The same is the case with citron, lemon, vervain, and orange peel, only these produce a stronger impression, or belong, so to speak, to a higher octave of smells. And again, patchouly, sandalwood, and vitivert form a third class. It requires, of course, a nice or well-trained sense of smell to perceive this harmony of odours, and to detect the presence of a discordant note. But it is by the skilful admixture, in kind and quantity, of odours producing a similar impression, that the most delicate and unchangeable fragrances are manufactured. When perfumes which strike the same key of the olfactory nerve are mixed together for handkerchief use, no idea of a different scent is awakened as the odour dies away; but when they are not mixed upon this principle perfumes are often spoken of as becoming *sickly* or *faint*, after they have been a short time in use.† A change of odour of this kind is never perceived in genuine eau de Cologne. Oils of lemons, juniper, and rosemary are among those which are mixed and blended together in this perfume. None of them, however, can be separately distinguished by the ordinary sense of smell; but if a few drops of hartshorn be added to an ounce measure of the water, the lemon smell usually becomes very distinct.

But though, as I have said, each volatile essence is chemically distinct, and possesses properties peculiar to itself,

* *Report of the Juries of the Great Exhibition of* 1851, p. 608.

† SEPTIMUS PIESSE, *Annals of Pharmacy and Chemistry*.

among which the odour is one, yet the delicacy and fragrance of this odour is found to vary considerably with the locality in which the plant that yields it has been grown. Thus on the shores of the Mediterranean, near Grasse and Nice, the orange tree and the mignonette bloom to perfection in the low, warm and sheltered spots: while, in the same region, the violet grows sweeter as we ascend from the lowest land and approach to the foot of the Alps. So lavender and peppermint grown at Mitcham, in Surrey, yield oils which far excel those of France or other foreign countries, and which bring eight times the price in the market. This effect of soil and climate on the odour of plants resembles that which they exercise in so remarkable a manner on the narcotic constituents of tobacco, opium, and hemp.*

The small proportion of volatile oil which many flowers yield by distillation has led to other modes of extracting it for use in perfumery. The flowers are moistened with olive or other oil, or with pomatum, and, after lying for a while, are submitted to pressure; or they are put into hot water and well shaken, with a portion of oil or pomatum, which is afterwards skimmed off. In either way the oil or fat is impregnated more or less strongly with the odour of the flowers, and has acquired a proportionate value. This process is called maceration, *enfleurage*, &c., and fats so perfumed are generally called French pomatums. Spirit of wine extracts the odoriferous principle from these scented fats, and the solutions are employed for the manufacture of perfumed waters.

The economical importance of these essential oils may be judged of from the facts that,

In 1852 there were imported into this country of essential oils about 200,000 lb. weight, paying a duty of 1s. a-pound;

Eau de Cologne to the value of £20,000 sterling;

* See THE NARCOTICS WE INDULGE IN.

French pomatums and other perfumery valued at £2200;
And that the total duty of every kind paid in Great Britain, for scents and perfumes, has been calculated at £40,000 a-year.*

2°. Compositions of the Volatile Oils.—A large number of the odoriferous essences of plants is composed of the two elementary bodies, carbon and hydrogen only. And what is very remarkable, many of them, which are otherwise very distinct, consist of these two elements united together in the same proportions. Thus a hundred pounds of pure oil of turpentine consist of—

Carbon,	88.24 lb.
Hydrogen,	11.76
	100 lb.

And the oils of lemons, of oranges, of juniper, of rosemary, of copaiba, of the queen of the meadow, and many others, though so different in their properties from the oil of turpentine and from each other, consist of exactly the same proportion (88½ lb.) of carbon united to the same weight (11¾ lb.) of hydrogen. Substances thus differing in properties, and yet agreeing in composition, are distinguished among chemists

* The quantities of essential oils paying 1s. a-pound duty entered for home consumption in 1853 were as follows:—

Bergamot,	28,574 lb.
Carraway,	3,602
Cassia,	6,163
Cloves,	595
Lavender,	12,776
Lemon,	67,348
Mint and spearmint,	163
Otto of roses,	1,268
Peppermint,	16,059
Thyme,	11,418
Lemon grass, Citronella, Oils not described,	47,380
	195, 346 lb.

The otto of roses comes chiefly from Constantinople and Smyrna; the oil of lemons from Sicily and Portugal; bergamot in large proportion from Sicily; and anise from Germany and the East Indies. The oil of cloves imported is small in quantity; but the consumption is probably ten times as much, the English wholesale druggists being themselves large distillers of this oil. Carraway is also largely distilled at home, while of oil of lavender probably as much as 6000 lb. are distilled in England, besides much oil of peppermint.

by the name of *Isomeric* bodies. The difference of properties they exhibit is believed to be a consequence of the unlike ways in which the minute molecules or atoms of the carbon and hydrogen are arranged and grouped together in the different compounds.

Another class of these volatile odoriferous oils contains a small proportion of oxygen combined with the carbon and hydrogen of which they chiefly consist. To this class belongs the volatile oil which bitter almonds (fig. 77) yield when distilled with water. This fragrant oil is very different from the fixed oil which almonds, both sweet and bitter, yield when submitted to pressure, and is much used by the confectioner and cook.

Fig. 77.

Amygdalus communis, var. *amara*—The Bitter Almond.

Scale, 1 inch to 20 feet.
Scale for flowers, leaf, fruit, stone, and kernel, 1 inch to 3 inches.

Fig. 78.

Cinnamonium zeylanicum—The Cinnamon Laurel.

Scale, 1 inch to 20 feet.
Scale for leaf, 1 inch to 4 inches.
Fruit, natural size.

Of the same kind is the oil of cinnamon, which the young bark of the cinnamon laurel (fig. 78) yields when distilled with water; and also the oil which is obtained from anise seed by a similar process. But in this class, the proportions

of the several constituents are rarely the same in two different oils. Thus the three oils above mentioned consist respectively of—

	Oil of Anise.	Oil of Cinnamon.	Oil of Bitter Almonds.
Carbon, . . .	81.08	81.81	72.4
Hydrogen, . .	8.11	6.07	13.8
Oxygen, .	10.81	12.12	13.8
	100	100	100

Oil of peppermint and many others belong to this class. They all differ from one another in composition, the proportions of the three ingredients varying in each case.

3°. Artificial Essences.—It is a character of all the volatile oils of the kinds above mentioned, that they cannot as yet be formed or imitated by chemical art. The progress of chemistry, however, has recently made us acquainted with one odoriferous essence, somewhat peculiar in kind, which *can* be prepared by an artificial process; and this is probably only the forerunner of many similar discoveries by which our power over matter is hereafter to be enlarged.

Fig. 79.

Spiræa ulmaria—The Queen of the Meadows.
Scale, 1 inch to 1 foot.

I have already mentioned the volatile oil of the queen of the meadow (*Spiræa ulmaria*), *fig.* 79, as having the same composition as oil of turpentine. But when the flowers of this plant are distilled with water, they yield, besides this oil, another sweet-smelling substance, known as the *essence of spiræa*, which differs from the oil in its properties, has a different composition, and contains oxygen. This essence resembles in its odour the oil of bitter almonds, and is remarkable for possessing acid properties.

Hence it is known to chemists by the name of salicylous *acid*.

When water is boiled upon the bark of the willow tree (*salix*), it extracts from the bark a bitter substance, to which the name of salicine is given, and which possesses many of the fever-dispelling virtues of the well-known quinine. When this bitter substance is heated along with bichromate of potash and sulphuric acid, it is converted into essence of spiræa or salicylous acid. Thus we have a method of forming this essence without the use of the natural flowers of the spiræa itself. And although this method is too expensive to be adopted on a large scale for the manufacture of the essence for practical purposes, it holds out the prospect, and will probably lead to the discovery of cheaper methods, by which not only this, but more valuable perfumes also may be prepared in an economical manner.

Indeed we already possess processes, by means of which we can imitate, at a cheap rate, though not actually form, another of the volatile oils above mentioned—the volatile oil of bitter almonds. This oil, as is well known, is highly prized, extensively used, and comparatively costly. The methods by which it is imitated are as follows:—

First, When common coal is distilled in our gas-works, a quantity of tarry matter (coal tar) comes over along with the gas which is used for lighting our streets. When this tarry matter is again distilled by itself, a thin, very combustible liquid, known as coal naphtha, is obtained. This coal naphtha is a mixture of various substances, one of which is a very light colourless liquid, distinguished by the name of *benzole*. When this benzole is carefully mixed with nitric acid (aquafortis), it unites with it and forms a sweet scented compound (*nitro-benzol*), which in odour and general appearance can scarcely be distinguished from oil of bitter almond. It is known and sold in commerce under the names

of *artificial oil of bitter almonds*, and of *Essence de Mirbane.* It differs in composition from the true volatile oil of bitter almonds; but it resembles it very closely in odour, and is an excellent substitute for it in the scenting of soaps. It is also safer than the natural oil for use in confections and cookery, because it can never contain the prussic acid which is sometimes present in the natural oil.

The *second* mode of imitating this volatile oil has recourse to substances of a very different origin. The urine of the horse and the cow contains an acid substance which is easily extracted from it in the solid state, and which is known to chemists by the name of *hippuric acid.* When this acid is heated over a lamp, it melts, and at 460° F. the melted acid begins to boil. There then distills over a liquid substance, containing 13 per cent. of nitrogen, to which the name of *nitro-benzyl* has been given. The odour of this liquid is so similar to that of the volatile oil of bitter almonds that it may readly be mistaken for it. We may expect it therefore to be used in perfumery instead of the more costly oil. For as the drainings of our stables and cow-houses are plentiful, and the hippuric acid can be cheaply extracted from them, the fragrant nitro-benzyl may be manufactured at a moderate cost.

The thoughtful reader will rightly appreciate the tendency and social importance of results and researches such as these, with which modern chemical investigations abound. They tend to give a new value to waste materials, by discovering new uses for them, and to cheapen at the same time, and bring within reach of the many, the luxuries and material refinements heretofore confined to the few.

4°. The Camphors, Balsams, and Odoriferous Resins are all more or less solid, possess a fragrance more or less agreeable, and always contain oxygen as one of their constituents. By combination with oxygen, many of the

Fig. 80.

Laurus camphora—The Camphor Laurel. or Camphire tree.
Scale, 1 inch to 20 feet.
Scale for flower and leaf, 1 inch to 4 inches.

volatile oils become changed into resins.

a. The *Camphors.*—There are several known varieties of camphor. The two most familiar in commerce, are the camphor of Japan, called also Dutch camphor, because it is usually brought to Europe by the Dutch, and the China or Formosa camphor. Every part of the camphor tree (*Laurus camphora*), fig. 80, is impregnated with the perfume. It is extracted by chopping the branches and boiling them in water; the camphor rises to the surface, and becomes solid, when the water is afterwards allowed to cool.

The odour of the camphors is powerful, very characteristic, and to many persons very agreeable. It is used for scenting soaps, tooth-powders, and numerous other preparations for the toilet.

What is called Borneo camphor is obtained from a different tree (*Dryobalanops*), but by the action of nitric acid is converted into common camphor. An artificial camphor also is prepared from oil of turpentine; but it does not possess the composition or fragrance of the laurel camphor, and cannot be used as a substitute for it.

b. The Balsams are thick, more or less fragrant, fluids, which, like the common turpentines, are obtained by mak

ing incisions into the bark of the trees which yield them. The balsam of Peru, and the balsam of Tolu, which are among the best known, are extracted in this way from different species of myrospermum which grow in Peru, New Granada, and on the banks of the Magdalena in South America. They consist chiefly of an odoriferous volatile oil, which comes over when they are distilled alone, and of a resin nearly void of smell which remains behind. The balsam of Peru has a powerful but agreeable odour, resembling that of vanilla. The balsam of Tolu is very fragrant, though less powerfully so than that of Peru. The fragrance of both is increased, and somewhat changed, when they are dropped on a red hot coal. While burning, the inodorous resin decomposes, and gives off an agreeable scent.

For their natural odour these balsams are used to flavour marmalades and other sweetmeats, and as an ingredient in various perfumes. For the additional scent they give off when burned, they are employed as incense, and in preparing the fumigating pastiles which we burn in the chambers of the sick and elsewhere to disguise or overpower unpleasant smells.

c. *The odoriferous resins*, such as myrrh and frankincense, have comparatively little natural fragrance. The balsamic resins, such as storax and benzoin, have more decided odours, and, like the true balsams, recall the sweet smell of vanilla. Like the camphors and balsams, all are used to some extent in preparing articles for the toilet.

But it is for the odours they evolve when burned that they are chiefly used and valued. When thrown in the state of powder upon burning charcoal, myrrh, frankincense, aloes, benzoin, storax, olibanum, and other resins of this kind, emit an agreeable fragrance. Hence they are largely used for burning as incense in the Greek and Roman churches and in Pagan temples. When burned in this way,

three effects are produced—*First*, The volatile oil is driven off in vapour, and diffuses through the air the scent emitted by the resin in its natural state. *Second*, White vapours of a volatile fragrant acid, which exists ready formed in the resin,* ascend and mingle their smell with that of the volatile oil. And, *thirdly*, Another volatile aromatic oil is produced by the decomposition of the resin upon the red hot charcoal The vapours of this oil also rise and unite with those of the other substances, and thus produce the full effect upon the olfactory nerves for which the most esteemed varieties of incense are valued.

d. Vanilla.—I have described the balsams as possessing an odour which resembles that of vanilla (fig. 81). This highly-prized perfume resides in the pods of an orchidaceous plant (*Vanilla aromatica* or *planifolia*), long known to the ancient Mexicans for its remarkable fragrance, and probably used by them, as it is now, for flavouring their favourite chocolate. The best vanilla is still brought from Mexico, though less esteemed varieties are produced by species of the plant which grow in other parts of tropical America. The fruit of this plant, as shown in the annexed figure, is a long pulpy pod, filled with rounded seeds. When ripe, the pod is said to yield from two to six drops of a liquid which has an exquisite odour, and bears the name of balsam of vanilla. This balsam, however, is never seen in Europe. The pods are dried in the sun, and afterwards slightly fermented, for the purpose of developing their odour, as, when fresh, they are said to be without smell. In some places

* From benzoin the fragrant *benzoic* acid is given off—from storax, and the balsams of Peru and Tolu, the *cinnamic* acid. The benzoic acid is white, solid and crystalline; and, though so different in its properties, is remarkable for possessing the same chemical composition as the volatile essence of spiræa already described. It is often used as an ingredient of pastiles. The cinnamic acid is very like the benzoic, and derives its name from the fragrant oil of cinnamon, which, by combining with oxygen, forms cinnamic acid.

they are afterwards rubbed over with oil, and in this state sent to market.

Fig. 81.

Vanilla aromatica—The Aromatic Vanilla.
Scale for plant, 1 inch to 6 feet.
Scale for flowers and fruit, 1 inch to 6 inches.

The odoriferous principles of the vanilla have not yet been accurately determined. One of them is a peculiar fragrant volatile oil, and another a fragrant acid, probably the cinnamic. Hence the similarity of the odour of vanilla to that of the balsams.

As a perfume, vanilla is highly esteemed. Its principal use, however, is in flavouring chocolate, ices, creams, and other confectionery. Coffee, and even tea, are sometimes also flavoured with it. Physiologically, it acts upon the system as an aromatic stimulant, exhilarating the mental functions, and increasing generally the energy of the animal

Fig. 82.

Dipterix odorata—The Tonka Bean tree.
Scale, 1 inch to 40 feet.
Leaves and raceme of flowers, 1 inch to 4 inches.
a. flower; *b.* kernel or bean; *c.* pod or fruit. 1 inch to 2 inches.

system. Like some other odours—those of camphor and patchouli, for example—that of vanilla sometimes exhibits narcotic effects upon those who are much exposed to it.

Five or six hundred weight of vanilla are yearly imported into this country.

e. Coumarin.—Nearly allied to the fragrant resins is an interesting and widely diffused natural perfume, to which chemists have given the name of *coumarin.* A fragrant bean, the Tonka or Tonga bean (fig. 82), the fruit of the *Dipterix odorata*, formerly well known in this country, and much employed for perfuming snuff, contains this substance *coumarin.* Alcohol readily extracts it from the bean; and by evaporating the alcoholic solution, we obtain the substance in a solid state. It forms white brilliant needles, possessed of an agreeable aromatic odour. When heated, it rises in vapour; and this vapour, when inhaled, acts powerfully upon the brain. It consists of carbon, hydrogen, and oxygen in the following proportions:—

Carbon,	73.97
Hydrogen,	4.11
Oxygen,	21.92
	100

Fig. 83.

Anthoxanthum odoratum—
Sweet-scented vernal grass.
Scale, 1 inch to 9 inches.
Single flower, glume, and seed, natural size.

So that it is richer in oxygen than any of the volatile oils of which the composition has been given above.

But the interesting circumstance in the history of this substance is, that, though discovered first in a foreign bean, the produce of a warm climate, it has since been found to exist in, and to impart their well-known agreeable odours to, several of our most common European plants. Among these, the sweet-scented vernal grass (fig. 83), to which we are in the habit of ascribing the fragrance of well-made hay, deserves especial mention. This grass contains coumarin, and imparts to dry hay the odour of this substance.

The following is a list of the sweet-smelling plants in which coumarin has already been found :—

Dipterix odorata, or Tonka bean.
Angræcum fragrans, the Faham tea-plant of Mauritius.
Asperula odorata, the common sweet woodruff.
Anthoxanthum odoratum, the sweet-scented vernal grass.
Melilotus officinalis, or common melilot.
Melilotus cærulea, the blue or Swiss melilot.

It is the same odour, therefore, which gives fragrance to the Tonka bean, to the Faham tea of the Mauritius, to our melilot trefoil, and to sweet-smelling hay-fields, in which melilot and vernal grass abound. In Switzerland the blue melilot is mixed with particular kinds of scented cheese, and the coumarin it contains gives to that of Schabzieger its peculiar well-known odour.

Many other sweet-smelling grasses are known, such as

Hierochloe borealis, Ataxia horsfieldii, Andropogon Iwacancusa, Andropogon schoenanthus or lemon grass, &c. &c., in which coumarin probably does not exist. Indeed, the Andropogon muricatus (the kuskus of India) yields a favourite fragrant oil, used as a medicine in that country. There are other sweet-smelling substances therefore, without doubt, from which grasses dried for hay, in different countries, may derive an agreeable odour.

I have alluded to the influence which, in the form of vapour, coumarin exercises upon the brain. It is not improbable that the hay fever, to which many susceptible people are liable, may be owing to the presence of this substance in the air in unusual quantity* during the period of hay-making. In seasons which are peculiarly hot, and in localities where the odoriferous grasses occur in uncommon plenty, such an abundance of coumarin vapour in the air is by no means unlikely to occur.

* Such fevers may possibly arise also from the diffusion through the air of the pollen of these odoriferous plants. This pollen is supposed, like that of the kalmias and rhododendrons, to possess narcotic properties, and, when drawn in by the nose and mouth, to produce narcotic fever-causing effects upon the system.

CHAPTER XXV.

THE ODOURS WE ENJOY.

THE VOLATILE ETHERS AND ANIMAL ODOURS.

Wine ether, how prepared.—Nitric ether and acetic ether.—Wood spirit and wood ether.—Potato spirit, or oil of grain, and potato ethers.—Oil of winter-green, a natural ether; how prepared artificially.—Sweet-smelling ethers manufactured as perfumes.—Pear oil, or essence of jargonelle.—Apple oil.—Grape and cognac oils. —Pine-apple oil —Essence of melons.—Essence of quinces.—Hungarian wine oil, and other artificial fragrances.—Caprylic ethers.—The flavour of whisky.—Propylic ethers.—The bouquet of wines.—Œnanthic ether gives the generic flavour to grape wines.—Characteristic fragrant principles of different wines.—Use of the sweet flag in flavouring spirits and beer; its abundance in Norfolk.—Odoriferous substances of animal origin.—Musk; the musk deer; lasting smell of musk.—Civet.—Effect of dilution upon odoriferous substances.—Use of civet in Africa.—Castoreum and hyraceum.—Ambergris and perfumes prepared from it.—Insect odours.—General reflections.—Extreme diffusiveness of odours.—Delicacy of the organs of smell.—How chemistry increases our comforts, gives rise to new arts, and generally civilizes.

II.—The Volatile Ethers yielded by plants are at the present moment the most interesting to the chemist of all the natural perfumes. This interest arises from the circumstance that a careful analytical examination of some of those produced in living plants, has given us the key not only to the true chemical composition of these substances themselves, but also to the mode of producing by art an almost endless variety of odoriferous compounds.

1°. Wine ethers.—When spirit of wine (alcohol) is mixed with twice its bulk of common oil of vitriol (sulphuric acid) in a retort, and distilled by the aid of heat, a very light, volatile, and somewhat fragrant liquid passes over, which is known by the name of *ether*, or wine ether. It differs in composition from alcohol only in containing less of the elements of water.

If into the retort, along with the alcohol and sulphuric acid, a sufficient quantity of nitrate of potash (saltpetre) be introduced before the mixture is distilled, the nitric acid of the saltpetre* unites with the ether as it is produced, and a *compound ether* distils over, which is the nitric ether of the shops. This consists of wine ether and nitric acid combined together, and is very light, volatile, and not unpleasantly odoriferous. If, instead of saltpetre, acetate of potash be introduced into the retort, acetic acid unites with the ether during the distillation, and acetic ether, another volatile ethereal compound, distils over.

By similar processes many other acids may be made to unite with wine ether, producing in each case a new compound ether, possessed of a composition and properties peculiar to itself.

2°. Wood ethers.—When dry wood is distilled in iron retorts for the manufacture of wood vinegar, there comes over, along with the tar, water, and vinegar, a quantity of a peculiar alcohol, which is separated and sold under the name of wood spirit.

When this wood spirit is distilled with the sulphuric acid, as in the first of the processes above described, a peculiar ether comes over, which is known as wood spirit ether, or wood ether. This ether differs from wood spirit as wine

* Nitric acid, known commonly by the name of aquafortis, unites with potash, and forms *nitrate* of potash, or saltpetre. Acetic acid (vinegar) and potash form *acetate* of potash.

ether does from wine spirit (common alcohol), in containing less of the elements of water. From wood spirit, compound ethers, also containing the simple ether combined with an acid, may be formed nearly in the same way as they are formed from the wine spirit. These compound ethers have a general resemblance, in properties and composition, to those formed from the wine spirit; but each of them possesses a peculiar composition and sensible properties, by which it can be distinguished more or less readily from every other compound body.

3°. POTATO ETHERS.—When brandy is manufactured from potatoes,* there comes over along with it, in the first distillation, a quantity of a third peculiar spirit of alcohol, which is known as potato spirit. It exists also in the crude spirits distilled from grain,† and from grape husks (p.280), and gives to these varieties of brandy their disagreeable flavour. By rectification it is separated from the brandy, and may thus be obtained in a pure state. It is more unpleasant to the taste and smell, and more maddeningly intoxicating than wine alcohol: and hence the peculiar, violent, and often poisonous effects, produced by ill-rectified grain and other raw spirits.

When this potato spirit is distilled with oil of vitriol, it also yields a peculiar volatile ethereal liquid—the potato-spirit ether, or briefly the potato ether; and by processes similar to those already described, compound ethers are readily obtained, in which this potato ether is combined with the nitric, the acetic, and many other acids.

For certain chemical reasons, which it is unnecessary here to state—

Wine spirit is called also		*Ethylic alcohol.*
Wood spirit	. . .	*Methylic alcohol.*
Potato spirit	. . .	*Amylic alcohol.*

* See pp. 201, 778.

† Hence it is called also *oil of grain*, and by the Germans *Fusel oil.*

In like manner—

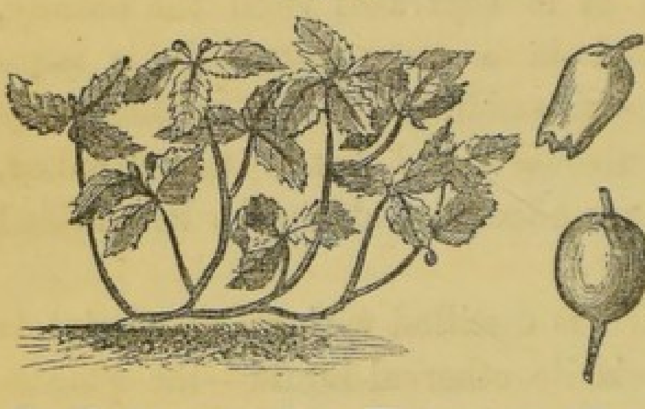
Wine ether is called *Ethylic ether*, or *Oxide of ethyle.*
Wood ether ... *Methylic ether*, or *Oxide of methyle.*
Potato ether ... *Amylic ether*, or *Oxide of amyle.*

And the compound ethers they severally form are named after the acid and ether they respectively contain. Thus the common nitric-ether I have mentioned is *nitrate* of oxide of ethyle, common acetic ether the *acetate* of oxide of ethyle, and so on.

With the aid of this preliminary explanation, the non-chemical reader will readily understand and appreciate all that follows regarding the progress and actual position of our knowledge on the subject of ethereal perfumes.

4°. Oil of winter-green.—In the State of New Jersey, in North America, the partridge-berry, tea-berry, or winter-green (*Gaultheria procumbens*), fig. 84, grows abundantly in the woods and drier swamps. It is a dwarf evergreen fragrant heath - plant, and possesses an agreeable aromatic odour resembling that of the sweet birch. It has long been gathered and to distilled, like other fragrant plants, for the sake of the volatile oil, which in this way may be extracted from it. This natural essence is largely imported into Europe as a perfume, and is known in commerce by the name of *oil of winter-green*

Fig. 84.



Gaultheria procumbens—Winter-green of New Jersey.
Scale, 1 inch to 5 inches.
Flower and fruit, natural size.

Only a very few years ago, a French chemist (M. Cahours), in experimenting with this oil, discovered that, unlike the sweet-scented volatile oils usually yielded by

plants—those of peppermint, cinnamon, anise, juniper, &c.—this was a compound body belonging to the known family of compound ethers, and, like them, was capable of being decomposed and again re-compounded by chemical art. This was the first step in a new direction, and opened up a new field of practical inquiry, which, though as yet only partially cultivated, has already yielded most unexpected fruits.

I have already spoken (p. 476) of the bitter substance *salicine*, which by a peculiar process can be converted into the fragrant essence of spiræa. By another simple process this salicine is converted into a solid crystalline acid substance, the salicylic acid; when combined with wood ether, the salicylic acid forms oil of winter-green.* This compound is produced naturally in the *Gaultheria procumbens;* but the same esteemed perfume, now that we know its nature, we can also make by art. But the salicine required in the process is too costly to admit of its being economically employed, as yet, for the manufacture of this oil.†

5°. Artificial sweet-smelling ethers.—Chemical research, however, had meanwhile been discovering in the laboratory other compound ethers, not yet known to occur in nature, but which were distinguished by smells so sweet as to entitle them to be placed amongst valuable perfumes. Many of these have already a well-established place in the market, and have become articles of extensive and profitable manufacture. Thus, under the name of—

a. Pear oil, or essence of jargonelle pears, is sold a spirituous solution of acetate of amyle oxide, the compound of vinegar with potato ether.‡ This ether, when pure, has

* Or the salicyl*ate* of oxide of methyle.

† Salicine is largely extracted from willow bark, and is but little used in this part of Europe. It is employed, however, in preference to quinine amid the marshes of the Danube in Turkey, and in the Eastern Archipelago—being less stimulating, and therefore better suited to the constitution and circumstances of the native inhabitants of these parts of the earth. This outlet for the salicine keeps up its price.

‡ Prepared, as already described, by distilling potato spirit with oil of vitriol and acetate of potash.

a peculiar fruity smell, but when mixed with six times its bulk of spirit of wine, it acquires the peculiar pleasant odour and flavour of the jargonelle pear! Whether the pear, when ripe, really contains any of this ether, is not known. It is largely manufactured, however, chiefly for the use of the confectioners. Among other purposes, they employ it to flavour pear-drops, which are merely barley-sugar flavoured with an infinitesimal quantity of this ether.

b. Apple oil, again, is a compound of the same potato or amylic ether, with an acid known to chemists by the name of the *valerianic*. It is easily prepared, by substituting the *bi*-chromate of potash for the acetate of potash employed in the manufacture of pear-oil. The pure ether becomes the commercial apple-oil when it is dissolved in five or six times its bulk of alcohol. It has then a most agreeable flavour of apples, and is employed largely by the confectioners.

c. Grape oil and *cognac oil* are also compounds of the amylic or potato ether with acids. They are used for giving the desired cognac flavour to British-made and other inferior brandies: what acids they contain is not yet known to chemists.

It will strike the reader as not unworthy of remark, that the same potato-spirit which, because of its offensive smell and taste, is carefully removed by the rectifier from the ardent spirits he distils, should, under the hands of the chemist, become possessed of the most agreeable and coveted fragrance!

d. Pine-apple oil, again, is common wine-ether combined with butyric acid, and then dissolved in alcohol. It has the pleasant flavour of the pine apple, and is employed in England to flavour an acidulated drink or lemonade called pine-apple ale. In Germany it is used to flavour bad rums.

The butyric acid contained in this compound ether is the substance which gives its peculiar, agreeable odour to fresh

butter. One mode of preparing the ether is to make butter into a soap, and to distil this soap with alcohol and sulphuric acid.*

This ether cannot be safely employed in perfumery for handkerchief use. When frequently inhaled, it produces a disagreeable irritation of the air-tubes of the lungs, which, when prolonged, is followed by intense headache. It is well adapted, however, for many of the purposes of the manufacturing perfumer, and as a flavouring material to the confectioner it is invaluable.

e. Essence of melons is a compound of wine ether with the coccinic acid, an acid which exists in cocoanut oil. It may be prepared in the same way as the pine-apple oil, substituting only, for the butter soap, a soap made from cocoanut oil.

f. Essence of quinces is wine ether combined with pelargonic acid. When dissolved in alcohol it possesses, in the highest degree, the agreeable odour of the oil which is extracted from the peel of the quince. It is most easily obtained by distilling oil of rue with diluted nitric acid (aquafortis).

g. Hungarian wine-oil is wine ether in combination with a peculiar acid called the œnanthic acid. This compound exists in all grape wines, and, when extracted, is employed for flavouring an artificial cognac which can scarcely be distinguished from the genuine. For this purpose it was very lately on sale in Breslau, at the price of sixty-nine dollars a pound! It was prepared in Hungary—whence its name—and was distilled from wine husks. It has recently been examined by Schwartz, who, besides making out its

* Another mode is, to mix sugar or starch with powdered chalk and a little curd of milk in water, and set it aside. The curd gradually causes the sugar to change, first into lactic acid, and then into butyric acid, which combines with the lime of the chalk. This butyr*ate* of lime, distilled with alcohol and sulphuric acid, gives the pine-apple oil.

composition and chemical relations, has also suggested a cheap process by which it may hereafter be abundantly prepared.

h. Other artificial fragrances.—The above are only samples, so to speak, of the almost endless variety of artificial compound ethers, possessed of sweet smells, which are either already manufactured, or are capable of being so, easily and cheaply for use as perfumes.

There are, for example, many other acids which are capable of uniting with each of the three simple ethers I have mentioned, and of forming with them compounds possessed of agreeable odours. We know already that the formic and hippuric acids* each yield, when united with the wine and wood spirit ethers, very agreeable perfumes which are still nameless; and the number of similar compounds which may be formed with other acids is almost inexhaustible.

Then, besides the three simple ethers prepared from wine, wood, and potato spirits, there are many other simple ethers, not so commonly known as these, each of which, with the same host of acids, forms compounds of a more or less odoriferous character. Thus—

Caprylic ether, or oxide of capryle, yields with acetic acid a compound of a most intense and pleasant smell. Those which it forms with other acids are still scarcely known, but many of them are remarkable for their aromatic odour. To the drinkers of whisky it may be interesting to know that the peculiar flavour of this liquor is believed to be due to the presence of a compound of this caprylic ether.† Again—

Propylic ether, or oxide of propyle, when combined with

* The formic acid is the acid of ants, but it can also be formed artificially. The hippuric acid is extracted from the drainings of stables.

† Caprylic ether is prepared from one of the acid substances contained in butter. The peculiar turpentine manufactured in some parts of Germany from the Scotch fir (*Pinus sylvestris*), very closely approaches the oil of whisky in smell. This, however, is merely a variety of turpentine, and not an ether.

butyric acid, yields a pure odour of ananas (pine apple) superior to that which the same acid gives when combined with wine ether. And many other sweet smells, still unknown, will no doubt become familiar to us when the compounds of this singular substance are further investigated.*

6°. THE BOUQUET OF WINES.—Among the odours we enjoy is to be reckoned the bouquet of our favourite wines. This bouquet is owing mainly to the presence of one or more volatile ethereal oils, similar to those I have above described.

Generally speaking, the peculiar character of a wine is dependent upon at least two volatile compounds possessed of odours more or less distinct. One of these is common to all good grape wines, the other is characteristic of the kind of wine, sometimes even of the sample we are examining. As in a well-made eau-de-Cologne, the excellence of a bouquet, or the value it imparts to the wine which possesses it, depends very much upon the way and degree in which the odours of these several compounds harmonise and flow into each other.

When a vinous liquor of any kind is submitted to distillation, it yields, besides common wine-alcohol, a portion of a peculiar ether, to which the name of œnanthic† ether has been given. It is the same as the Hungarian wine-oil already described, and consists of common wine-ether united to a peculiar acid, the œnanthic. This ether, when pure, possesses the characteristic odour of grape wine in so very high a degree as to be almost intoxicating. It gives what may be called the fundamental or generic flavour to all grape wines.

* Propylic ether, or oxide of propyle, is prepared from another fatty acid—the propionic; and I have called it a singular substance because, while this oxide of propyle yields delightful odours, another compound of the same propyle yields repulsive smells, like those of boiled crabs, herring brine, and stinking fish.

† From *Οινον*, wine; and *Ανθος*, a flower.

But if the residue of the wine—that which remains after the alcohol and œnanthic ether have been distilled off—be mixed with quicklime and again distilled, a volatile odoriferous substance passes over, which possesses in a high degree the peculiar bouquet of the wine we are examining—(WINCKLER).* Every variety of wine, when treated in this way, yields its own peculiar and characteristic fragrant principle. This specific bouquet, in combination with the general vinous odour of the œnanthic ether, common to all wines, produces the full effect on the senses of smell and taste for which each particular wine is distinguished and esteemed. The rapidity with which the bouquet of a wine is lost, depends partly upon the greater or less volatility of the peculiar odoriferous substances it contains, and partly on the ease with which they oxidise, or otherwise change, when exposed to the air.

Little is known as yet with regard to the true chemical nature of these specific odoriferous substances. They are said by Winckler to possess basic or alkaline properties, to contain nitrogen, and to exist in the wines in combination with peculiar volatile acids. They are always associated with the œnanthic ether above described, but are not ethers themselves. When they have been more fully examined, they may probably make us acquainted with another large family of agreeable odours. And the questions will then naturally arise—Can we prepare these substances by artificial processes?—Can we teach the wine manufacturer to flavour at will one pipe with the bouquet of Lafitte, and another with that of Johannisberg?—and so on.

I need scarcely observe that the practice of flavouring brandies and beers, so as to give them an esteemed bouquet, has been long known and extensively practised. I have already mentioned certain compound ethers—the Hungarian

* *Chemical Gazette*, January 1853, p. 36.

wine-oil, and the pine-apple oil for example—which are employed to give the flavour of cognac or of rum to inferior spirits, and the use of juniper in the manufacture of gin is known to every one. A less familiar flavourer is the sweet flag, the *calamus* of the Song of Solomon (fig. 85). This imparts at once an aromatic taste and an agreeable bouquet odour to the liquid in which it is infused. It is used by the rectifiers to improve the flavour of gin, and is largely employed to give a peculiar taste and fragrance to certain varieties of beer. It abounds in the rivers of Norfolk, and from this locality the London market used to be principally supplied. As much as £40 is sometimes obtained for the year's growth of a single acre of the river-side land, on which it naturally grows.

Fig. 85.

Acarus calamus.—The Sweet Flag.
Scale, 1 inch to 10 inches.

III. Animal Odours.—Most species of animals emit from their skin an odour peculiar to themselves, by which other animals, keen of scent, can recognise and trace them. The blood and flesh of animals also possess a peculiar smell, and only long habit prevents us from distinguishing in this way the flesh of the ox, the sheep, and the pig. The parts of animals have rarely so powerful an odour as to cause them on that account to be either rejected or selected for economical purposes. It is different with the secretions of animal bodies. Some of these are offensively disagreeable to the sense of smell, while others are sought after and

valued as agreeable perfumes. Among the latter, musk civet, and ambergris are the most important.

Fig. 86.

Moschus moschatus—Musk Deer.

1°. Musk is a substance which is found secreted in a small bag, attached to the under part of the body of a ruminating animal of the size of a roebuck (fig. 86), which inhabits the mountains of China, Thibet, Tonquin, Tartary, and Siberia. It is obtained only from the male animal. When fresh, it is in the state of a soft, salve-like, reddish-brown mass. It possesses a peculiar, penetrating, long-continuing odour, and a bitter, astringent, aromatic, slightly saline taste. By keeping, it dries, becomes blackish-brown, and assumes the form of little rounded grains, which give a brown streak upon paper, and are easily rubbed to powder. It is one of the most powerful, most penetrating, and most lasting of odoriferous substances. It attaches itself, and gives a durable scent to every thing in its neighbourhood. Different qualities of musk are met with in the market, and from its high price it is very liable to adulteration. When pure, it dissolves in water to the extent of three-fourths of the whole.

The chemical nature of musk is not thoroughly understood. It contains several less valuable ingredients, the general properties and origin of which are known; but the chemical characters and composition of that ingredient which emits the valuable odour have not yet been rigorously investigated. As is the case with the special bouquet of wine, it appears to consist of a volatile acid united to a

volatile alkali, which are separated from each other by distillation with lime—(WINCKLER). Imperfect as our knowledge of musk at present is, however, observations already made render it probable that, before many years have elapsed, we shall be able to produce it by art.

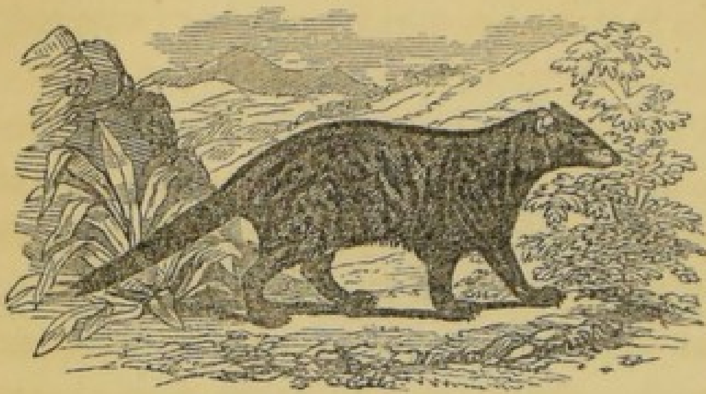
So persistent and apparently indestructible is the odorous principle of musk, that when taken internally, as it frequently is in cases of spasms, it passes through the pores of the skin, and impregnates the perspiration with a strong smell of musk. When kept in capsules of wax, however, or in contact with lime, with milk of sulphur, with sulphurate of gold, or with syrup of almonds, musk loses it smell. But in all these cases the smell is restored by moistening it with liquid ammonia (hartshorn).

The flesh of the crocodile is said to smell of musk, and the same odour is sometimes emitted by plants. Thus our common beet has a musky smell, and the musk-plant of our gardens possesses it more distinctly. But the *Delphinium glaciale*, a plant which grows on the Himalayas at the height of 17,000 feet, has so strong and disagreeable a smell of musk, that the natives believe the musk deer, which is found on the mountain slopes, to derive its smell from eating this plant. Another Delphinium, the *D. brunonianum*, which grows on the western slopes of the Himalayas, has a similar smell of musk, though less disagreeable —(HOOKER). The nature of the musky-smelling substances contained in these plants is not yet known.

About six thousand ounces of musk are imported into this country every year, besides that which comes from China and Russia—(POOLE). Each natural pod or sac weighs only six drachms, less than half of which consists of musk. It is somewhat remarkable that while this scent is so much esteemed in England and other countries, it is extensively disliked in Italy, and makes many persons ill.

2°. Civet.—The substance known in commerce by the name of civet, is secreted by two animals of the genus Viverra, (*V. zibetha* and *V. civetta*), one of which is a native of Asia, and the other of Africa. It is of a pale yellow or brownish colour, has usually the consistence of honey, and possesses a somewhat acrid taste. Its smell resembles that of musk. When undiluted, this smell is so powerful as to be offensive to many; but when mixed with a large quantity of butter, or other diluting substance, it becomes agreeably aromatic, fragrant, and delicate.* It is used only as a perfume, and chiefly to mingle with, and improve the odour of, less costly scents. Lavender and other scented waters are made more agreeable by a skilful addition of civet, in minute proportions.

Fig. 87.



Viverra civetta—Civet Cat.

Over Northern Africa, between the Red Sea and Abyssinia, the civet cat, called by the Arabs *kedis*, is highly valued. Numbers of them are kept in wicker cages for the pursose of collecting the civet they secrete. It is used by the women for the purpose of powdering the upper parts of their body, their necks, &c. Its strong odour overpowers the disagreeable effluvium which often escapes from their dusky skins in that arid climate.†

* It throws some light upon the diversity of taste which prevails in regard to scents, that the same substance may be agreeable in a diluted, which is offensive in a concentrated state. The volatile oils of neroli, thyme, and patchouli are in themselves unpleasant, but when diluted with a thousand times their bulk of oil or spirit, their fragrance is delightful. So the odoriferous ethers require to be diluted with six times their weight of alcohol.

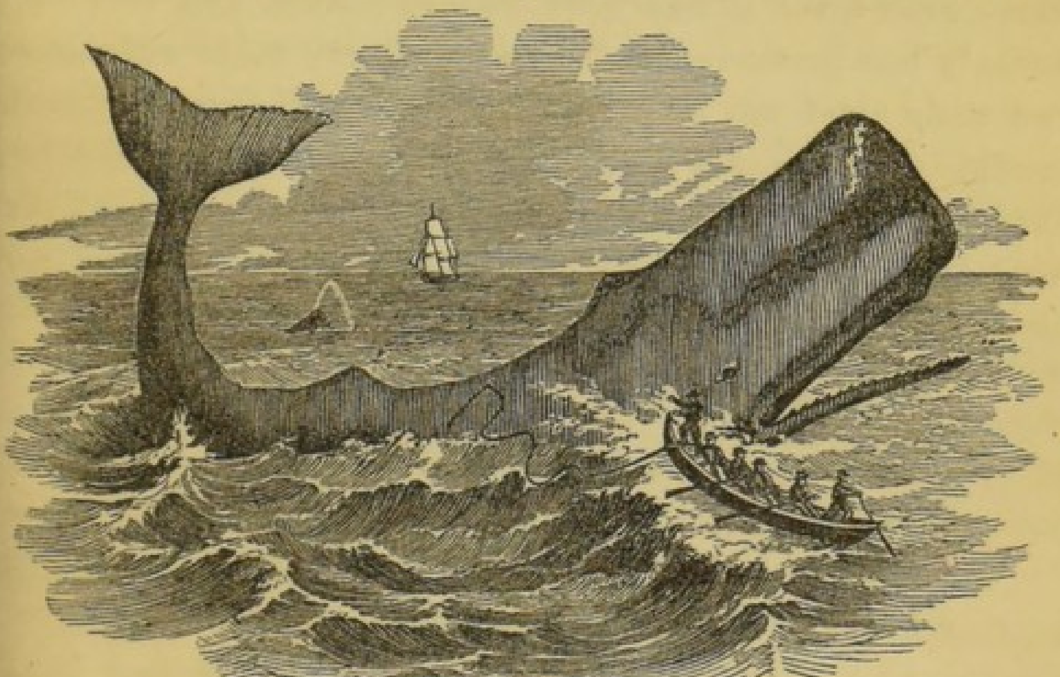
† Werne's *African Wanderings* (*Travellers' Library*), pp. 187, 260.

Castoreum, yielded by the beaver, is a natural secretion, similar in its origin and its properties to musk and civet. Like these substances, it has, when fresh, a powerful penetrating odour, and a bitter acrid taste. The odour, however, is fetid and disagreeable: it is only used in medicine, therefore, and never as a perfume.

Hyraceum is a similar substance obtained from the mountain badger (*Hyrax capensis*). It resembles castoreum in smell, and is sometimes used medicinally in its stead.

3°. AMBERGRIS is an odoriferous substance which is found floating on the sea near the Molucca Islands, in other parts of the Indian Ocean, and off the coast of South America. It is believed to be rejected by the spermaceti whale (*Physeter macrocephalus*), in which it has sometimes been found.

Fig. 88.



Physeter macrocephalus—Spermaceti Whale.

When fresh, ambergris is solid, greyish, streaked or marbled, and somewhat soft. It has a strong agreeable odour, resembling that of musk, and a fatty taste. It con-

sists, to the amount of six-sevenths of the whole (eighty-five per cent), of a fragrant substance, soluble in alcohol, to which the name of *ambreine* has been given, To this principal ingredient its use as a perfume is owing.

Ambergris is rarely employed alone. The essence of ambergris of the perfumer is an alcoholic tincture of the substance, to which the oils of roses, cloves, &c., are added, according to fancy. What is called *tincture of civet* is formed by macerating half an ounce of civet with a quarter of an ounce of ambergris in a quart of rectified spirit. Either of these tinctures, added in minute quantity to lavender water, to tooth-powder, hair-powder, toilet soaps, &c., communicates to them the peculiar odour of ambergris.

In fixity and permanence of scent the animal odours are unrivalled. A handkerchief scented with ambergris retains the odour even after it has been washed: musk and civet are scarcely less permanent. To this property these substances owe their chief use in perfumery. They impart to volatile handkerchief-scents a smell which continues after the less fixed ingredients have disappeared. A favourite mixed perfume of this kind, the *extrait d'ambre* of the Parisian perfumes, is compounded of—

Esprit de rose triple,	½ pint
Extract of ambergris,	1 "
Essence of musk,	½ "
Extract of vanilla,	2 ounces.

When well perfumed with this, a handkerchief, though washed, retains an odour still.

The high price which ambergris, like musk and civet, brings in the market, leads to frequent adulterations, both in this country and in those from which it is imported. The chemistry of this substance is not yet so well understood as to justify us in hoping soon to produce its odoriferous ingredient by artificial processes. Yet the observation, that dried

cow-dung smells of ambergris—(REDWOOD)—and that even nightsoil, under certain forms of treatment, assumes a powerful odour of this substance—(HOMBERG)*—suggest lines of research, by following which a mode of manufacturing ambergris may hereafter be discovered.

4°. INSECT ODOURS.—Among animal odours of an agreeable kind, those given off by certain insects are deserving of mention. To entomologists, many strong-smelling insects are known, though some of these, of course, are far from being agreeable to our senses.

Fig. 89.

Cerambyx moschata.
Half natural size.

The *Cerambyx moschata* (fig 89), a coleopterous insect, derives its specific name from the musky odour it emits. Most of the ants of Europe give off, when crushed, a well-known penetrating odour of formic acid: those of Bahia in South America, which are very troublesome and destructive, give off when squeezed a strong smell of lemons—(WETHERELL). The *Gyrinus natator* of Linnæus has so strong an odour, that, when several of the insects are collected together, they may be scented at a distance of five or six hundred paces—(RAESEL). It is to the eating of these insects that Mr. Lloyd † is inclined to ascribe the remarkable odour emitted by the grayling (*Thymallus vulgaris*), which by different writers has been likened to that of thyme or of honey.

I do not multiply examples of this kind, as nothing is yet known as to the chemical nature of the odoriferous substances which insects emit; nor have any of them as yet been employed for purposes of luxury or economy.

Many reflections are suggested by the facts I have

* *Memoirs of the French Academy*, 1711.
† *Scandinavian Adventures*, i. 128.

brought together in the present chapter. Want of space forbids me to indulge in more than one or two.

First. One circumstance which presses very strongly upon our attention, is the extremely minute state of diffusion in which the odoriferous substances of animal origin still make themselves perceptible to our senses. A fragment of musk not only gives off a strong smell when it is first exposed to the air, but it continues to do so for an almost indefinite period of time. Yet the odour must be caused by particles of matter which are continuously escaping from the musk, so long as it continues exposed to the air. How inconceivably small in weight, how infinitely minute in size, the molecules must be of which this constantly-flowing stream of matter consists!

And to vegetable perfumes the same observations almost equally apply. A morsel of camphor will for days fill a large room with its scent without suffering any material diminution in weight. A single leaf of melilot will for years preserve and manifest its sweet odour, and yet the quantity of coumarin it contains would probably be inappreciable by the most delicate balance. We know in this country how a stalk of mignonette, placed in an open window, will scent the air that enters, through the whole of a long summer's day. But in hot climates, especially during the morning and evening hours, this diffusiveness of perfumes is still more striking. "The odour of the balsam-yielding Humeriads has been perceived at a distance of three miles from the shores of South America—a species of Tetracera sends its perfume as far from the island of Cuba—and the aroma of the Spice Islands is wafted out to sea."*

The quantity of ethereal oil which gives its peculiar aroma to grape wine has been estimated at one-forty-

* Mrs. Somerville's *Physical Geography*, ii. 122.

thousandth only of the bulk of the wine, and that which gives the aroma to roasted coffee, at one-fifty-thousandth of its weight; but the ozone which exists in the atmosphere is distinctly perceptible to the smell when mixed with five hundred thousand times its bulk of air.

Second. The nicety of the bodily organs by which we perceive these extremely diluted perfumes is equally a subject for admiration. The sense of smell detects and determines the presence of these infinitesimally minute molecules. This is remarkable. But it does much more. It distinguishes between them, pronouncing the impression it derives from one class to the agreeable, and from another class the reverse. It then further pronounces upon the amount and kind of the pleasurable sensation produced by each, and this through a long series of varieties and degrees. How delicate the structure of the organs of smell must be! How suprising that they should continue uninjured and unimpaired, amid so much thoughtless usage, and for so long a series of years!

Third. This history of the odours we enjoy illustrates in a remarkable manner, how, out of the most vile materials, chemistry, by its magical processes, can extract the sweetest and most desirable substances. How wonderful this power, how delightful to possess it, how useful its results! Artificial musk and ambergris! Manufactories of oil of bitter almonds! Essences of spiræa and winter-green prepared in chemical laboratories! Humble wines successfully flavoured to compete with the produce of the most costly vintages! Ethereal fragrances without number, and unknown by name, added to the list of enjoyable odours! Pleasing scents, in cheap abundance, of which the wealthiest in ancient times could form no conception, and which they had no means of obtaining!

This history presents, in truth, another striking illustra-

tion of the way in which modern chemical research leads to the establishment of new arts and manufactures—to the addition of new and unknown luxuries to those already within our reach—to the cheapening of luxurious comforts to all,—and thus to the refining, and softening, and polishing of the whole community. It displays, also, to the reader the existence of a new field of practical and economic research which is almost boundless, shows how valuable chemistry is in almost every walk of life, and how the studies of the laboratory may be made a source even of money profit in the most unexpected departments of economic pursuit.

CHAPTER XXVI.

THE SMELLS WE DISLIKE.

NATURAL SMELLS.

Difference of opinion as to smells.—Disagreeable mineral smells.—Sulphuretted hydrogen; its properties, and production in nature.—Sulphurous acid given off from volcanoes; its suffocating reputation.—Muriatic acid gas.—Unpleasant vegetable smells.—Garlic and the onion.—Oil of garlic.—Sulphuret of allyle.—Sulphur an ingredient of many fetid smells.—Assafœtida, a concrete juice.—Oil of assafœtida. —Extensive use of vegetable substances containing allyle; they satisfy some natural craving; extensive distribution of them in nature.—Horse-radish and mustard also contain allyle.—The stinking goosefoot.—The peculiar strong-smelling compound contained in this plant exists also in putrid fish; economical use of it in the cuisine.—Carrion plants.—The saussurea and the stapelias.—Smells often disagreeable only because of the things or memories associated with them.—Disagreeable animal odours; the goat, the badger, and the skunk.—Effects of minute doses of sulphur and tellurium.—Stenches as weapons of defence.—Insect smells. —The putrefaction of animal bodies; conditions which promote it; substances given off; their unwholesome character.—Burying-vaults and graveyards.—The droppings of animals; peculiar substances and smells given off by these.

THE smells we dislike are probably quite as numerous as the odours we enjoy. Between the two, however, there is a wide debatable ground, in regard to which the utmost diversity of opinion prevails. What is fragrance to one person is sometimes abomination to another. Plutarch tells us that a Spartan lady paid a visit to Berenice the wife of Dejotarus; but that one of them smelled so much of sweet oint-

ment, and the other of butter,* that neither of them could endure the other; and it is so still, even among the most cultivated and refined. For although cultivation may very much improve this taste, and though individual constitution modifies in a certain degree the effect which odoriferous substances produce upon the organs of smell, yet early habit determines for the most part the judgments we form as to the agreeable and the disagreeable.

Still, as there are certain odours which nearly all persons enjoy, so there are certain smells which almost every one dislikes. These are distinctly indicated by the old English word *stinks.* Of these acknowledged bad smells some are produced naturally, while others are the result of artificial processes. In the present chapter I shall consider only the bad smells which occur in nature. Of these some are of mineral, some of vegetable, and some of animal origin.

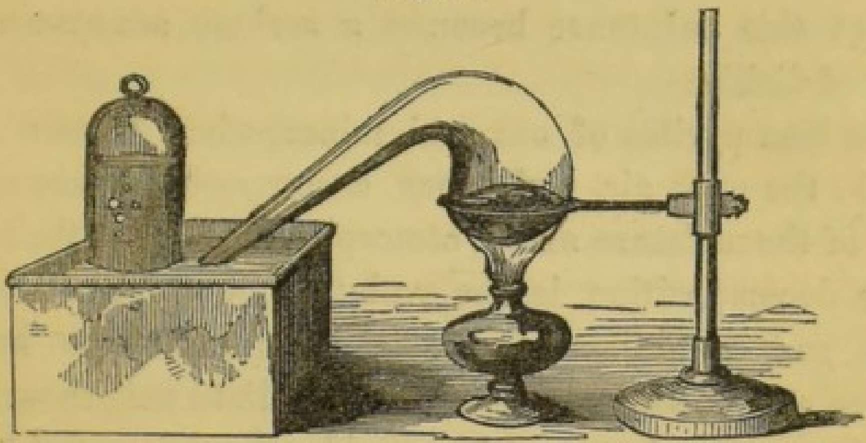
I. Mineral Smells.—Of disagreeable mineral smells, the most common are sulphuretted hydrogen and sulphurous acid. The former gives its disagreeable smell and taste to sulphureous mineral waters, like those of Harrogate; the latter is given off from the mouths of active volcanoes, and from cracks and fumaroles in volcanic countries. Muriatic acid is also occasionally discharged by active volcanoes.

1°. *Sulphuretted Hydrogen.*—When common sulphur and iron-filings are melted together in a red-hot crucible, they combine chemically, and form a black *sulphuret of iron.* If this black substance be put into a flask or retort, along with diluted sulphuric acid (oil of vitirol), a gas is given off, generally without the application of heat. This gas consists of sulphur and hydrogen, and is therefore called sulphur-

* The use of butter came to the Greeks from Thrace and Phrygia, and to the Romans from Germany. They used it only in medicine and as an ointment in their baths.—Beckman, Art. *Butter*

etted hydrogen. This gas may be collected over water in the usual way, (fig. 90). It has no colour, but is distinguished by a sulphury taste, and a strong fetid sulphureous smell

Fig. 90.



resembling that of rotten eggs. It is about one-fifth heavier than common air, burns with a blue flame and a smell of sulphur, and is very poisonous when breathed. A single gallon of it, mixed with 1200 of air, will render it poisonous to birds, and one in a hundred will kill a dog. A very small proportion of it, therefore, mingled with the air we breathe, will render it injurious to human health. Water dissolves two and a half times its bulk of this gas, and acquires at the same time its smell and taste.

This gas is often produced naturally in the interior of the earth, and, rising upwards through the rocks, is absorbed by springs, and gives them the unpleasant smell familiar to us in many mineral waters. It is the sulphuretted hydrogen they contain which causes these waters to blacken when mixed with those of other springs which contain iron.

From marshy and stagnant places also, where vegetable matter is undergoing decay in the presence of water containing gypsum (sulphate of lime), this gas is often given off; and its smell may in most cases be perceived in moist soils, where gypsum lies in contact with decaying roots and leaves. In volcanic countries, it frequently issues from the earth in

larger quantities. From fissures and openings in the solfataras of Italy, for example, as in that of Puzzuoli, it rushes out, mixed with steam and other gases, and diffuses its fetid odour sometimes to great distances. In such localities the smell of this substance becomes a serious annoyance and source of dislike.

The iron pyrites of our coal mines, when thrown up in heaps in the open air, undergoes decomposition through the action of the moisture of the atmosphere. One of the results of this decomposition is the evolution of sulphuretted hydrogen gas, sometimes in sufficient quantity to be both offensive and unwholesome to the immediate neighbourhood.

This gas consists, as I have said, of sulphur and hydrogen only, in the proportions, in a hundred parts, of—

Hydrogen, ...	5.9
Sulphur, ...	94.1
	100

So that a comparatively small proportion of hydrogen causes sulphur to assume the gaseous form, and to exhibit the fetid odour and remarkably poisonous properties possessed by this gas.

2°. *Sulphurous Acid.*—When sulphur is kindled in the air, it burns with a pale blue flame, and is converted into a heavy acid vapour or gas, which is distinguished by a peculiar suffocating smell. This is well known as the smell of burning sulphur. It is formed by the union of the sulphur with its own weight of the oxygen of the atmosphere, and is called by chemists sulphurous acid gas. It is two and a fifth times heavier than common air; and when inhaled, it first provokes cough, and if continued, causes suffocation.

This gas is given off from the mouth of active volcanoes, from vents and fissures in the earth in volcanic countries, and from the solfataras which often exist where volcanic action is going on. It is not less disliked for its smell than

sulphuretted hydrogen is, and it is even more suffocating when breathed.

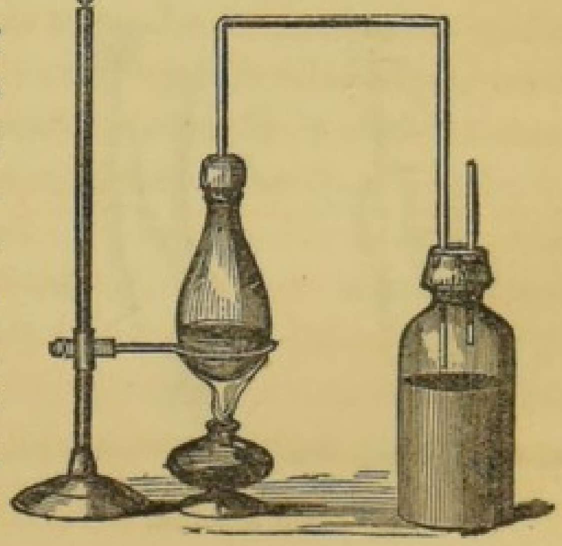
The universal dislike of this gas is indicated by the place so generally assigned to it, in figurative descriptions, of a future place of torment. Thus, in the Book of Revelations, we have "the lake which burneth with fire and brimstone, which is the second death;" and in Milton s description, it is a place

"Where peace
And rest can never dwell; hope never comes,
That comes to all; but torture without end
Still urges, and a fiery deluge, fed
With *ever-burning sulphur*, unconsumed."

3°. *Muriatic Acid Gas.*—When oil of vitriol (sulphuric acid) is poured upon common salt, white vapours are given off, which provoke cough, are very suffocating, and affect the sense of smell in an exceedingly unpleasant manner. These are vapours of muriatic acid, or *spirit of salt.* They are absorbed by water with great rapidity; and when conducted by a bent tube into a bottle of water (fig. 91) till the latter is saturated, they form the strongly corrosive acid liquid usually known by the name of spirit of salt.

Vapours of this gas are sometimes given off from the mouths of active volcanoes; but they rarely prove an annoyance to the neighbouring population. The two most common and best known evil smells of mineral origin, therefore, are those of the sulphuretted hydrogen, and the sulphurous acid gases. Of these, the former is by far the most widely diffused, and the most frequently observed, and is

Fig. 91.

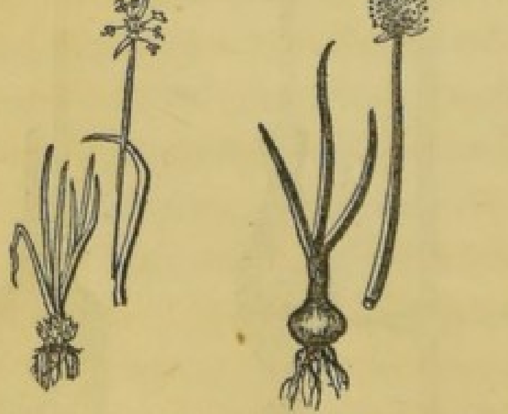


productive of the most general annoyance. The sulphurous acid gas is naturally produced only in the neighbourhood of volcanoes, or where sulphur, by some natural means, is made to burn in the air.

II. Vegetable Smells.—Of the smells we dislike, a much greater number are of vegetable than of mineral origin; and of these, some are given off by living plants, which produce and contain essential oils, to which their smells are owing. Among these, I advert more particularly to the garlic tribe, the assafœtida plant, and the stinking goosefoot, both because they all emit smells which, in a concentrated form, are generally considered very unpleasant, and because the chemistry of the evil-smelling substances they contain is at present better understood than that of any other known substances of the same kind and origin.

1°. *Garlic and the Onion.*—A familiar plant in many of our moist woods and shady meadows is the common ramps, or ramsons (*Allium ursinum*). When in flower, this plant diffuses its disagreeable garlic odour through the air, and imparts its unpleasant flavour to the milk of the cows that feed upon it. When distilled with water in a retort, a heavy volatile oil passes over and collects beneath the water, which condenses in the receiver. The common onion, the chive, the chalot, the leek, the common garlic, and other species of this strong-smelling tribe of plants, yield the same oil when distilled with water.

Fig. 92.



Allium sativum—The Cultivated Garlic. | *Allium cepa*—The Common Onion.
Scale 1 inch to a foot.

This oil is of a brownish-yellow colour, is heavier than water, and possesses the pe-

culiar smell of the class of plants which yields it, but in a highly pungent and concentrated form. It is their strong-smelling principle or ingredient; and the strength of its odour may be judged of from the fact that, powerfully smelling as garlic is, from thirty to forty pounds of it are required to yield one ounce of the oil.*

We have seen that a large class of the volatile perfumes which are extracted from plants—such as the oils of roses, lemons, &c.—consist of the two elementary substances, carbon and hydrogen only. In this fetid oil of garlic there also exists a volatile substance consisting of carbon and hydrogen only, to which, from the generic name (*allium*) of the plants in which it is found, the name of Allyle has been given. This substance, however, instead of an agreeable, has a very unpleasant smell. It combines with sulphur also, and forms with it a volatile oil possessed of an intensely fetid odour. This compound is called by chemists *sulphuret of allyle;* and it is this substance which exists in garlic, and gives both to garlic and the onion their peculiar smell. The chive, the chalot, the leek, the rocambole and the onion (*Allium leptophyllum*), which is eaten by the hill people of India, all derive their smell from the same sulphur-containing oil of garlic. The relative mildness of these several vegetable productions, as well as that of different varieties of the common onion, depends upon the proportions of garlic oil they severally contain. And the bad smell of the breath after eating any of these plants is caused by the constant presence of a small quantity of this oil among the air we exhale from our lungs.

This strong-smelling compound, by the intensity and persistence of its odour, reminds us of the animal perfumes—musk, civet and ambergris—described in the preceding chapter. Like musk, also, it exudes through the pores of

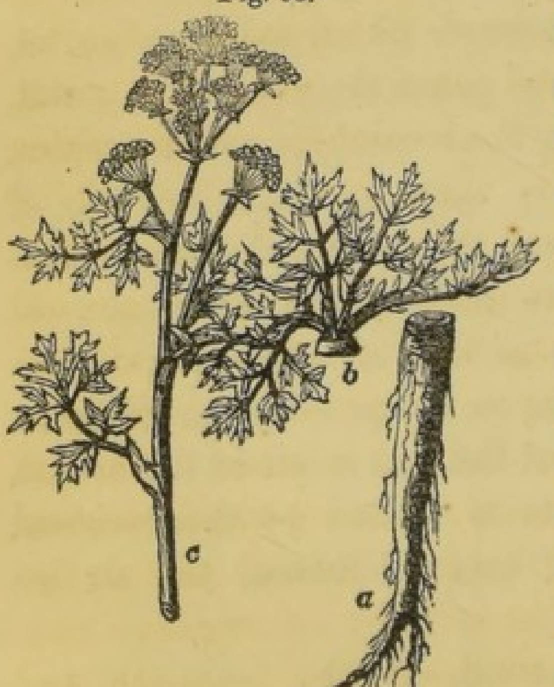
* A hundredweight of garlic will give three or four ounces of oil.

the skin of the garlic-eater, giving its smell to the perspiration; while, like the narcotic principles of opium,* it passes, probably unchanged, into the milk of the animals which swallow it. And both the intensity and adhesiveness of its odour are shown by the well-known fact that a knife which has been used to cut an onion retains for a long time, and communicates to other substances, the smell and taste of this oil.

It is not unworthy, also, of the attention of the reader, that, as the most fetid mineral smells I have described are compounds of sulphur, so this fetid vegetable oil of garlic is also a compound of sulphur (*sulphuret of allyle*). We shall have occasion to remark a similar connection of sulphur with other evil smells both natural and artificial.

2°. *Assafœtida* is the concrete juice of the *Ferula assafœtida.* It is collected by cutting the stalk of the plant across immediately above the root—as represented in the woodcut (fig. 93)—leaving the root in the ground, and scraping off the sap as it flows upwards, and dries on the cut surface. It possesses an odour similar to that of garlic, but still stronger, more fetid, and generally much more disagreeable to Europeans. On the borders of Asia, however, the concrete juice is not considered unpleasant. On the contrary, it is extensively collected, sold, and used as a condiment for food.

Fig. 93.



Ferula assafœtida—The Assafœtida plant. *a*, Root, with the crown cut off, to allow the gum to exude; *b*, Crown, with root-leaves; *c*, Flowering stem.

Scale, 1 inch to a foot and a half.

When this resinous substance is distilled with water

* See The Narcotics we indulge in.

it also yields a volatile oil in small quantity. On cooling, this oil becomes solid, and gives off, in a concentrated form, the fetid odour of the natural drug. Its smell has a certain resemblance to that of garlic, but it is, if possible, still more offensive; and it is remarkable that, in composition also, it resembles the oil of garlic. It contains the same peculiar strong-smelling body *allyle*, already spoken of, and also in combination with sulphur. The only difference in the composition of the two oils seems to be, that the oil of assafœtida contains a larger proportion of sulphur than the oil of garlic.

Three circumstances are interesting in conection with these compound oils and the condiments in which they occur.

First, That vegetable productions so unlike to each other as the onion, the garlic, and the assafœtida plants are, and growing in climates so different, owe their smell and taste to the presence of the same peculiar compound (*allyle*).

Second, That the fetid quality of the oils they severally contain is connected with the presence of sulphur in them as an essential part of their chemical constitution; and that the more fetid of the two—the oil of assafœtida—contains the largest proportion of sulphur.

Third, That without any knowledge of these close chemical relations among the plants in question, different races of men, in different parts of the world, have long selected and largely used them as condiments to their food. The Englishman, to a certain extent, relishes his onion, and the Frenchman mildly flavours his most savoury dishes with a touch of the garlic or chalot. But in Portugal and Spain the onion and the garlic are the relishes of common and everyday life. This taste the Peninsula has probably acquired from Northern Africa. Over the whole of the latter region—from the shores of the Mediterranean to the sources of the Nile—garlic and the onion are most esteemed seasoners of the universal food; Arab, Moorish, and Ethiopian

tribes equally delight in them;* and this taste is of very remote origin. The Israelites, during their sojourn in the wilderness, murmured, saying, "we remember the cucumbers and the melons, the leeks, the onions, and the garlic." Among the ancient Egyptians themselves, the onion formed an object of worship; and the modern Egyptians assign it a place in their paradise. To the present day, the onion of the Nile borders possesses a peculiar excellence and flavour. The Eastern Asiatics appear to require more powerful condiments. With them the assafœtida takes the place both of the milder onion, and of the stronger garlic.

Strange that the peculiar taste for these compounds of sulphur and allyle should so extensively prevail, and that vegetable productions, so unlike in external appearance, should have been selected for the purpose of gratifying it! As in the case of the beverages and the narcotics, men seem to have been led to this selection by a kind of human instinct, guiding them blindly, as it were, to plants which were capable of yielding to the body the same chemical compounds.

And to facilitate, as it were, the guidings of this instinct —to afford the means of gratifying the natural craving— these garlic-smelling compounds appear to be much more extensively diffused throughout the vegetable kingdom than physiologists are yet aware of. Several species of Petiveria, which are common in the West Indies, in Brazil, and on the eastern slopes of the Andes, are possessed of a strong garlic odour. Such is the case with the *Petiveria alliacea*, the guinea-hen weed of the West Indies; with the *P. tetrandra;* with the *Seguiera alliacea*, the root, wood and leaves of which have a powerful odour of garlic or assafœtida, and are employed to form medicated baths in Brazil; and with a species of

* Garlic and Salt, placed under the tongue, are considered by the Arab as a cure for thirst and fever.

Petiveria called *Ajo del monté*, which forms one of the giant ornaments of the Bolivian forests on the eastern slopes of the Cordilleras.

Future research will probably show that these compounds of allyle exercise a peculiar physiological action upon the system, by which certain of its natural cravings are allayed, and its general comfort promoted. This is rendered more probable by the remarkable circumstance that horse-radish and mustard—the use of which as condiments so extensively prevails—owe their peculiar properties to the presence of compounds of the same substance—allyle.

3°. *Horse-radish and Mustard.*—When the root of the common horse-radish is distilled with water, it yields a volatile oil, which possesses the pungent smell and taste of the natural root in a highly concentrated state. This smell is not disliked, I believe, by most people; but I mention the oil in this place, because it contains the same compound body, *allyle*, which exists in the oils of garlic and assafœtida. In the horse-radish, however, it is combined not only with sulphur, but also with a second substance known to chemists by the name of *cyanogen*. To the presence of this cyanogen the difference of properties possessed by the horse-radish are to be ascribed. The smell and taste of the oil it yields are very strong and pungent, but it has little of the fetid character which distinguishes those of garlic and assafœtida.

Mustard owes its peculiar penetrating odour, burning taste, and blistering quality, to the presence of the same volatile oil which is found in horse-radish. It exists also in scurvy grass (*Cochlearia officinalis*), in the roots of *Alliaria officinalis*, and probably in our common cress, rape, radish, and similar pungent tribes of plants. To the presence of this oil they most likely owe their peculiar pungent virtue; and, as in the case of those which possess the garlic smell, it is probably an instinctive consciousness of their salutary in-

fluence upon the system that has led to the extended use of them all in so many parts of the earth.

4°. *The Stinking Goosefoot* (Chenopodium olidum, fig. 94) is another plant which has been long known for its disagreeable smell. In botanical works, this smell is compared to that of putrid salt-fish. The substance to which this smell is owing, has recently become quite as interesting to the chemical physiologist as those which give their smell to garlic and assafœtida.

Fig. 94.

Chenopodium olidum—The Stinking Goosefoot.
Scale, 1 inch to 6 inches.

If a portion of this plant be distilled along with a solution of common soda, a volatile alkaline substance passes over, which has the smell of stockfish, of boiled crabs, of herring brine, or of Findhorn haddocks, which have been long kept. To this substance chemists have given the somewhat ponderous name of *trimethylamine.*

One of the interesting circumstances connected with this vegetable product is, that if herring brine be distilled in the same way along with soda, the same volatile substance passes over in still greater abundance than from the stinking goosefoot. In a living and growing plant, therefore, and in the substance of dead and decaying fish, one and the same chemical compound is naturally produced, and imparts to each the same well-known penetrating and offensive odour for which it is everywhere remarkable.

The history of this substance (*trimethylamine*) presents also an interesting illustration of the way in which chemistry throws light on natural phenomena. It was formed and obtained in the laboratory by special chemical processes, and its peculiar properties ascertained before it was extracted

either from the evil-smelling plant, or from the decaying fish. It was the smell of the artificial compound which suggested first that it might possibly be the cause of the repulsive odour of the living plant, and afterwards of that of the dead animal. Subsequent research showed the correctness of these conjectures, by actually extracting it from both by the processes I have described. As is the case with some of the natural vegetable perfumes, therefore, we can now prepare by art the stinking constituent of the goosefoot, should its production ever be likely to lead to profit.*

The interest which attaches to the disagreeable-smelling compounds of this class is very different from that which distinguishes the compounds of allyle. The latter have been sought for and used most extensively; the former have

* *Trimethylamine* is not the only substance known to be possessed of this fishy odour. Another volatile alkaline compound, called *propylamine*, is in smell scarcely distinguishable from trimethylamine. The two substances consist also of the same elements united together in the same proportions,—that is to say, they are *isomeric* (see above, p. 473). Their chemical relations, however, and their chemical constitution, are very unlike. The grouping of the six atoms of carbon (C), nine of hydrogen (H), and one of nitrogen (N), of which the two compounds consist, is thus represented respectively—

Trimethylamine.

$$\left.\begin{matrix} C_2 & H_3 \\ C_2 & H_3 \\ C_2 & H_3 \end{matrix}\right\} N$$

Propylamine.

$$\left.\begin{matrix} & H \\ & H \\ C_6 & H_7 \end{matrix}\right\} N$$

The sum being, $C_6 \; H_9 \; N$ — $C_6 \; H_9 \; N$

The meaning of this mode of rationally representing the composition of the two compounds, is this—

$C_2 \; H_3$ represents a substance called *methyl.*

$C_6 \; H_7$ " " *propyl.*

$H_3 \; N$ or $\left.\begin{matrix} H \\ H \\ H \end{matrix}\right\} N$ represents *ammonia.*

Now, if for one of the atoms of hydrogen (H) in ammonia, we substitute one of propyl, we produce propylamine, represented as above; or, if for each of the three atoms of hydrogen we substitute one of methyl, we have trimethylamine, also as above represented. Such substitutions we can actually make in our laboratories; and thus we are enabled to form a rational idea of the way in which compound bodies may contain the same elements in the same proportions, and yet differ very much from each other in properties.

been generally avoided; no instinct or experience of their good effects upon the system has hitherto led any tribe of men to seek after or indulge in the use of them.

I may suggest to the cook, however, as a possible use to which these fishy-smelling compounds may hereafter be put in the *cuisine*—the flavouring of *imitation* fish-cakes, crab, lobster, cray-fish, and oyster-patés, fish-sauces, such as the anchovy, &c. &c. Such preparations as these, by the application of a little skill, may pass off at table, and be made to please the palate as well as genuine salt-water productions, though containing nothing that ever lived in the sea!

5°. *Carrion Plants.*—As the goosefoot smells like putrid fish, so some plants smell like putrid flesh. The flowers of the bladder-headed *saussurea* have the smell of putrid meat: and the *stapelias*, because of their putrid and disagreeable odour, are distinguished by the name of carrion-flowers. The fermented juice of the Mexican agave also, which forms the pulque so popular in Central America,* is remarkable for its odour of putrid meat.

The chemical compound (or compounds) to which this carrion smell is owing, are still unknown. It is produced as a natural secretion, so to speak, in the living stapelias—as the result of fermentation in the juice of the agave—and as a consequence of putrefaction in dead and decaying flesh. It may either be the same substance which gives the smell in all these cases, or it may be caused by different substances of the same chemical nature—all belonging most probably to the same class of volatile alkaline compounds as the trimethylamine of the goosefoot and the stock-fish.

It is interesting to trace close chemical coincidences like these between vegetable and animal productions as regards even things subordinate and disagreeable. They

* See the LIQUORS WE FERMENT.

are at least more unexpected, and apparently less necessary, than those we have already had occasion to remark between the entire substance of the animal body, and the staple forms of vegetable food by which it is supported.*

We have seen in this and the preceding chapter how tastes differ in regard to sweet odours. The history of the Mexican pulque illustrates how the disagreeableness of a smell may also be a mere matter of taste. Some relish a slight taint in butcher meat, or a game flavour in wild animals, because it indicates, and is usually accompanied by, a greater tenderness of the flesh. And so, notwithstanding its fetid odour, the Mexican loves his native liquor, and rejoices in it above every other drink. We seem to love or detest the putrid taint, not because of any positively painful effect it produces upon our organs of sense, but because of the associations with which it is connected. Let the odour in early life remind the smeller of an agreeably acid, thirst-quenching and exhilarating liquor, and it will ever after come to his nostrils as an agreeable perfume. Let it first reach his sense of smell, and become familiar to him, as the repulsive emanation from a dead and decaying animal body, and it will always remind him thereafter of disagreeable death, of hated worms, and of the dread dissolution his own frame must eventually undergo. It will never be to him otherwise than as a noisome stench. So much are the indications of our senses dependent upon the circumstances in which, when consciousness first began to dawn upon us, we happened to have been placed.

III. Animal Smells.—Unpleasant odours natural to animals are familiar to the inhabitants of almost every part of the globe. The he-goat, the badger, and the polecat in

* See the Bread we eat, and the Beef we cook.

this country, the skunk in North America, the beautifully striped viverræ of the South American plains, and the great ant-eater from the same country, now to be seen in the zoological gardens, are each characterised by peculiar and unpleasant smells. Some of them, as they pass along, even sensibly infect the air with their pestilential odour.

In the case of the goat it is probably the perspiration from the skin in which the bad smelling substance resides. In the skunk it is lodged in a peculiar receptacle, from which the animal has the power of ejecting it at will—probably as a means of self-defence. The intensity and durability of the odour of the skunk remind us of the same properties in the more agreeable musk and civet, which are also of animal origin. The purpose of defence supposed to be served by the smell of the skunk, would seem to imply that it is naturally offensive to the senses, altogether independent of early association.

Fig. 95.

Mephitis Americana—
The Skunk.

Many other animals emit unpleasant odours from their skin, especially in the rutting season; but of the chemical nature or composition of the substances to which all these animal stinks belong, we are as yet entirely ignorant. One known chemical fact in regard to the smells themselves, however, is sufficiently remarkable. This is, that the entire effluvia given off by an animal is often affected not only by the general nature of the whole food that it eats, but by the introduction of most minute quantities of foreign substances into the stomach. Thus the swallowing of a little pellet of finely powdered sulphur frequently gives a decided and disagreeable smell to the whole skin, and for many days

after. And what is still more remarkable, a single grain of a compound of the metal tellurium administered to a healthy man, will make his neighbourhood perfectly intolerable for weeks, and sometimes even for months, after he has swallowed it.

Tellurium is still a comparatively rare substance, and we know little as yet of the combinations it is capable of producing with organic substances. So far, however, it appears probable that they are of a still more fetid and disgusting character than those produced by sulphur. With the compound allyle—already spoken of as the peculiar strong-smelling principle of garlic, assafœtida, and mustard —tellurium will probably form a compound body more intolerably offensive still than the oils of garlic or assafœtida. And if we cannot use such compounds as means of sensual gratification, it may not be impossible to employ them as weapons of offence or defence. Imitating the natural habit of the skunk in this respect, we might far surpass it in the intensity and offensiveness of our artificial stinks. Squirted from the walls of a besieged city, projected into the interior of a fortified building, or diffused through the hold of a ship of war, the Greek fire would be nothing to them; and as for the stink-pots of the Chinese, they must be mere bagatelles to the stenches we can prepare.*

As there are insects which give off agreeable odours, so many are known which emit disagreeable smells. That of the common bug tribe (*cimicidæ*) is probably more offensive, because of the unpleasant sensations which the smell recalls. The same is the case also with the tree bug (*pentatoma*), and with the flying bug, which is one of the insect pests of the Ganges about Benares. The last of these is a large hemipterous insect of the genus *derecteryx*, which insinuates

* See the succeeding Chapter, p. 532.

itself between the skin and the clothes. It diffuses a dreadful odour, which is increased by any attempt to touch or to remove it; but the natural dislike for its smell is no doubt increased by the other annoyances which the insect occasions.

In regard to the chemistry of insect stinks, nothing whatever is known.

IV. Smells produced by Decaying Substances.—The most numerous class of disagreeable smells is that which is produced by the decay or decomposition of animal and vegetable substances. Our dislike of these smells arises partly no doubt from their being associated in our minds with unpleasant sights and ideas, and partly from their being found by experience to be injurious to human health.

1°. *The Putrefaction of Animal Bodies.*—The general nature and odour of the ill-smelling substances produced during the putrefaction of animal bodies are determined by the sulphur and phosphorus which are contained in them. During their decay the sulphur combines with the constituents of the animal matter, and forms fetid compounds similar to those already described as occurring in the mineral and vegetable kingdoms. The phosphorus also enters into combinations scarcely less unpleasant and injurious. And with both of these classes of compound bodies are associated others peculiar to animal forms of matter, which have not yet been separately examined. All these unite in producing those mixed smells which distinguish so repulsively the natural decay of animal substances in the open air.

Of the presence of sulphur in such cases, a familiar example is presented by a rotten egg. When such an egg is broken, the smell of sulphuretted hydrogen is at once perceived, and a silver spoon put into it becomes black im-

mediately from the action of sulphur. As the decay proceeds, other smells gradually become sensible, and these mingling with that of the sulphuretted hydrogen, occasion that growing offensiveness which the rotting egg is known to exhibit.

In warm climates, decomposition of this kind proceeds more rapidly, and the strong-smelling substances are produced both sooner and in greater abundance. The intensity of the odours emitted, and the distances to which they are diffused through the air in hot countries, may be inferred from the extremely short period of time required to bring the vulture and the condor even from great distances. They scent afar off the decaying carcass, where the human organs refuse to give any indications of its presence.

Air, moisture, and a certain degree of warmth are necessary to the decay of animal bodies. If any of these three conditions be wanting, it either proceeds more slowly, or ceases altogether. Thus, in cool dry vaults, dug in an absorbent soil, and through which a current of dry air passes, human bodies sometimes become dry before they have had time to decay, and gradually shrivel up into frightful mummies.* So in the dry air of some hot climates, as in the Pampas of South America, and on the borders of the African deserts, the flesh of animals can be dried and preserved for any length of time, without exhibiting symptoms of decay, or any manifest evil odour.

But where moisture continues present—even though warmth and air be in a great measure excluded—decay still slowly takes place, and substances of evil odour and malign influence continue for a long period to be produced and given off. The true chemical nature and exact composition

* The reader who has spent a day at Bonn on the Rhine, will probably be reminded by this passage of the mummies in the church on the Kreuzberg, which strangers seldom fail to visit.

of many of the volatile and gaseous substances, produced under these circumstances, is still unknown; but both theory and experience prove that they are injurious to human health. They are so, even when, from their extreme state of dilution, the organs of smell are naturally insensible to their presence, or when, by habit, they have become so. Hence the custom of placing grave-yards in the neighbourhood of our dwellings, or of requiring people to sit for so many hours a-week over putrid family vaults, or heaps of mouldering human dust—is as contrary to the dictates of science and enlightened common sense, as it is to the often-repeated suggestions of sanitary experience. That the senses detect no danger, proves that the senses are not to be relied upon —not that even serious danger is absent.

2°. *The Droppings of Animals*, both while recent, and during the decay they undergo in the presence of air and moisture, are the source of some of the most unpleasant smells with which we become familiar in common life. These animal excretions emit certain strong-smelling substances which are common to them all, but each variety also gives off smells peculiar to itself.

a. When in a state of fermentation, for example, all evolve ammonia;* but it escapes in especial abundance from horse-dung in hot stables, and from nightsoil in ash-pits and necessaries during hot weather. All also produce and give off the noxious sulphuretted hydrogen already described; but where nightsoil ferments in close places, such as cesspools and common drains, this sulphureous gas sometimes accumulates in sufficient quantity to strike down instantly the workman who is incautious enough to place his mouth within its reach.† Compounds of phosphorus likewise escape

Ammonia is the substance which gives its smell to common hartshorn and smelling-salts.

† The best and most ready antidote, when sulphuretted hydrogen has been in-

from all, and volatile alkaline compounds, which have not hitherto been particularly examined.

b. When recent or fresh, on the other hand, each variety emits its own peculiar odour. The droppings of the cow and the horse differ most distinctly in smell, both from each other and from nightsoil. Goat's dung has a smell, which it imparts to plants manured with it, so as to give a perceptible flavour even to the tobacco leaf. Pig's dung is to most people nearly intolerable, and even animals dislike it. It not only gives its flavour to tobacco, but, when properly applied, it drives away the wireworm from the carrot and the onion. The reader will not be surprised to learn that the chemical nature and composition of the compound bodies from which these noisome smells proceed, should still be in a great measure unknown.* However interesting, in a physiological and sanitary point of view, it would be to possess a complete knowledge of all the substances which animal droppings contain—of the mode of their production—and of the nature of their several actions on the animal economy—we must be content to wait while it slowly and gradually collects. The inquiry is of too repulsive a nature to be undertaken by any chemist whose love of knowledge, or desire to advance a favourite branch of the science, is not of a very ardent kind.

There are certain known differences, however, in the com-

haled, is chlorine gas, prepared by wetting a thin towel with vinegar, sprinkling chloride of lime between its folds, and causing the patient to breathe through them.

* Among the peculiar organic compounds contained in fresh nightsoil, is a crystalline slightly alkaline substance, which has been named *excretine*, and an acid called the *excretolic* acid. They are extracted from fresh fæces by alcohol, but little is yet known of them. Excretine is not contained in the urine, nor is it ascertained if it is present in the contents of the small intestines. The droppings of herbivorous animals contain no excretine. Those of the carnivorous mammalia contain a substance resembling it, along with butyric acid, which is not present in nightsoil. Those of the crocodile contain cholesterine, and no urea; those of the boa, uric acid and no cholesterine—(MARCET).

position of the solid droppings of different animals, which must affect the nature of the smells they severally emit. Thus man discharges through his kidneys a large proportion of the phosphorus contained in the food he eats; while the cow, the horse, and the sheep, emit none of it in this way. All the phosphorus which these animals eat, therefore, is rejected in their solid droppings; and inasmuch as the compounds of phosphorus, which are formed in decaying animal and vegetable substances, are generally distinguished by peculiar and offensive smells, it is easy to understand that the droppings of these animals, when they heat and ferment, must emit some—more or less nauseous, and probably injurious—odours, which are not to be recognised in similarly fermenting nightsoil.

CHAPTER XXVII.

THE SMELLS WE DISLIKE.

SMELLS PRODUCED BY CHEMICAL ART.

Smells produced by chemical art.—Seleniuretted hydrogen.—Phosphuretted hydrogen.—Mercaptan.—Kakodyle.—Alkarsin.—Cyanide of Kakodyle.—Compounds of tellurium.—Interesting chemical relation between sweet odours and stinks.—Acrolein.—Offensive substances produced by destructive distillation.—Smells emitted by manufactories.—The sulphuric acid, soap, candle, vinegar, and glass makers.—Lead and copper smelters.—Such smells may and ought to be prevented.

V. Smells produced by chemical art.—In the preceding chapter, I have mentioned incidentally, that, though many natural smells are very offensive, yet that we can already produce others by art which are still more so. Indeed, were any useful purpose to be served by them, we could, by familar chemical processes, add stenches almost inconceivably disgusting to those which have hitherto been prepared. A reference to a few only of those which are now well known in our laboratories, will satisfy the reader as to the resources of the chemist in the production of stenches.

1°. *Seleniuretted Hydrogen.*—We have seen that sulphur is a substance which forms many combinations distinguished by their disagreeable odours; and of these I

have described sulphuretted hydrogen as one which both occurs in nature, and can be easily produced by chemical art.

Selenium is an elementary body which, though less abundant in nature than sulphur, resembles it very much in sensible and chemical properties. Like sulphur, it also combines with hydrogen, and forms a poisonous gas—the seleniuretted hydrogen. But this gas greatly exceeds the sulphuretted hydrogen, both in its evil smell, and in its noxious qualities. A single bubble of it allowed to escape into the air of a room, produces on those who breathe it all the usual symptoms of a severe cold and affection of the throat, and these symptoms do not pass off for several days. The singular virulence of this substance illustrates in a very striking manner the injurious influence which may be exercised over the health of the people by the presence of very minute portions of foreign bodies in the air we breathe.

2°. *Phosphuretted Hydrogen* is a gas in which phosphorus takes the place of the sulphur and selenium contained in the two gases above mentioned. It is easily prepared in the laboratory, and is possessed of a peculiarly fetid smell. It is one of the compounds of phosphorus also, which is naturally produced, along with other disagreeable substances, during the decay of animal bodies, and contributes to the repulsive character of the smells which decaying animal matter gives off.

The two metals, arsenic and tellurium, also combine with hydrogen, and form gaseous compounds—the arseniætted and telluretted hydrogens. These gases are of so fetid a kind that chemists rarely venture to prepare them; and when they do so, it is only after taking careful precautions against their escape into the air of the room in which the experiments are made.

It is a common character, also, of all the five gases I

have named, that they combine with other compound bodies, and especially with organic* compounds, producing new substances far more fetid than themselves, and possessed of stenches which cannot be described in words. To this class belong some of the following compounds :—

3°. *Mercaptan.*—Among organic substances of much importance in modern chemistry is a class of bodies to which the name of *compound radicals* is given. These bodies consist of two or more simple substances united together, and are therefore compound bodies; and yet behave, in many respects, as if they were themselves simple.† To this class of bodies belong those which I have had occasion to mention under the names of

ETHYLE,	as existing in	*wine ether.*
METHYLE,	"	*wood ether.*
AMYLE,	"	*potato ether.*
ALLYLE,	"	*garlic and mustard oils, &c.*

Among other properties which these compound radicals possess is that of combining with sulphur, and of forming with it new combinations of an extremely fetid character. Of this the sulphureous oils of garlic and assafœtida are natural examples.

When ethyle is combined artificially with sulphur, it forms what is called *sulphuret of ethyle*, and when this again is combined with sulphuretted hydrogen, it forms *mercaptan.* This latter substance is a colourless volatile liquid, possessed of a most offensive, penetrating, and concentrated odour of onions, which adheres obstinately to the hair and clothes. It is, in fact, an artificial oil of garlic

* By *organic* is meant such as are derived from the animal or vegetable kingdoms.

† That is, like the simple substances—hydrogen, chlorine, the metals, &c.—they unite with oxygen, sulphur, and other bodies, without being themselves decomposed, and form with them new compounds, possessed of acid or basic properties.

differing from the true oil of garlic, however, both in composition and in the special character of its smell.

Now, the important points to be borne in mind here, are—

First, That all the compound radicals are capable of combining with sulphur and sulphuretted hydrogen, and of thus forming substances analogous to this mercaptan.

Second, That the number of such organic radicals already known is very great. It is consequently in our power to form many mercaptans, all possessed of very offensive smells, but each distinguished by a shade of offensiveness peculiar to itself. The reader will by this example, therefore, see that in the compounds of sulphur alone the chemist has at his command a very large number of exceedingly foul smells.

4°. *Kakodyle.*—But arsenic may take the place of sulphur in all these fetid compounds, and produce new volatile substances of which the smell is absolutely insufferable, and which, besides, are deadly poisons. Kakodyle is the name given by chemists to the compound which arsenic forms with the radical *methyle*. When this volatile substance is exposed to the air it takes fire. As it burns the arsenic contained in it combines with oxygen, and forms white arsenic. This diffuses itself through the air, and when drawn in with the breath acts as a deadly poison.

5°. *Alkarsin.*—When white arsenic is distilled with acetate of potash, a liquid comes over which has been long known under the name of liquor of Cadet. It is volatile, possesses a peculiar garlic-like fearfully offensive, insupportable, long-enduring smell, and its vapours act as a deadly poison.

This liquor of Cadet is the substance kakodyle, above named, in combination with oxygen. It is known to chemists by the name of Alkarsin.

Because of their abominable smells, and dangerously

poisonous qualities, this class of arsenical compounds has been comparatively little studied. Several others, however, possessed of similar smells, are already known.* There is reason, therefore, to believe that most of the other compound radicals are capable, like methyle, of uniting with arsenic to form kakodyles, and these again with oxygen to form alkar sins—all fetid to smell and poisonous to breathe, but each of them offensive in a form and degree peculiar to itself. Arsenic will furnish us, in fact, with as many varieties of fatal kakodyles and alkarsins, as sulphur with purely fetid mercaptans.

6°. *Cyanide of Kakodyle.*—Even at this point, our chemical resources are not exhausted. Cyanogen is a compound gas which unites with hydrogen to form the deadly poison prussic acid. This cyanogen combines also with kakodyle, and forms what is called cyanide of kakodyle. Besides the fetid odour and fatal properties of kakodyle, this compound possesses a deadly quality peculiar to itself. When exposed to the atmosphere, it rises in the form of vapour. This vapour, by the contact of air and moisture, is immediately decomposed. The metal arsenic, with the oxygen of the moisture,† forms fumes of poisonous white arsenic, while, at the same time, the cyanogen unites with its hydrogen to form prussic acid. Thus through the air are diffused, at the same instant, vapours of the two most deadly poisons with which we are acquainted. Mercaptan and oil of garlic xpel us by their insufferable stench. The kakodyles and their cyanides arrest our flight by almost as suddenly depriving us of life.

In the preceding chapter I have alluded to the use of unbearable stenches as weapons of defence. The substances

* *Annal der Chim. & Pharm.*, lxviii. p. 127; SILLIMAN'S *Journal*, xv. p. 118.

† The reader will recollect that water, or watery *moisture*, consists of oxygen and hydrogen.

I there alluded to were simply disgusting smells, not acting upon the system as inevitable poisons. These kakodyles and their cyanides might certainly be employed still more efficiently in warlike operations; but how far the use of vulgar poisons in honourable warfare is consistent with the refinements of modern civilisation, is open to much doubt. There may not be much real difference between causing death by a bullet, and by the fumes of deadly poison; and yet, to condemn a man "to die like a dog," does array death to him in more fearful colours.

Among the deadly chemical combinations which have recently been spoken of as ingredients in the proposed *asphyxiating shells*, the kakodyles and their compounds have held a prominent place. Whether the proposers of such asphyxiating projectiles have considered this metaphysical distinction between different modes of compassing death, or whether it has weighed at all with those whose office it is to decide as to their adoption, we have no means of knowing. According to the received form of retribution, however, in all such cases, the chemist who first suggested the use of such poisons to manufacturers of ammunition, is destined to perish by his own new weapon of destruction.*

7°. *Compounds of Tellurium.*—I have already spoken of the metal tellurium as capable of producing compounds possessed of a most offensive odour. Almost the only experience we have as yet, however, of such compounds, is from the effects of certain odourless preparations of tellurium administered, by way of experiment, to persons in good health. Within the body of the patient it forms compound

* One of the most recent announcements on this subject in the newspapers of the present month (September 1854), is as follows: "The Committee of Ordnance have had their attention drawn to a new projectile. It is a shell charged with a liquid which, when released by the concussion of the ball, becomes a sheet of liquid fire, consuming all within its influence, the smoke emitted also destroying human life." The properties of the liquid here described are those of kakodyle.

—as sulphur not unfrequently does—which impart to his breath, to the perspiration from his skin, and to the gases produced in the alimentary canal, a disgusting fetor, which makes him a kind of horror to every one he approaches; and this lasts sometimes for weeks, though the dose of tellurium administered may not exceed a quarter of a grain.

Such compounds it is no doubt within the power of chemistry to produce by artificial processes, though few experiments have yet been made on the subject. These compounds belong to the class of pure stenches, and are not supposed to be poisonous as those of arsenic are.

Phosphorus also combines with organic radicals, and forms compounds more offensive even than the phosphuretted hydrogen already described. But these are as yet quite as little known as the analogous compounds of tellurium.

A curious general relation exists between the class of stenches to which those of the mercaptans and kakodyles belong, and one of the most esteemed groups of volatile perfuming bodies. This relation is both interesting and worthy of being remembered.

I have shown, in a preceding chapter, that a very large class of the odours we enjoy consists of *simple ethers combined with organic acids*. Now, these simple ethers are all combinations of one of the compound radicals already spoken of with oxygen. Thus—

ETHYLE with oxygen forms *wine ether*.
METHYLE with oxygen forms *wood ether*.

And these ethers, when combined with organic acids, form perfumes—the wine ether, for example, forming with butyric acid the pure apple oil, and with pelargonic acid the essence of quinces.*

* See THE ODOURS WE ENJOY

On the other hand, the same

> ETHYLE with sulphur forms a *sulphuret of ethyle*, and
> METHYLE with arsenic forms *kakodyle.*

Both possessed of evil smells themselves, but, when combined with acids containing sulphur or arsenic, forming combinations which are insupportably fetid.

The same compound radicals, as they are called, therefore, when united with oxygen, may produce pleasant impressions, and when united with arsenic or sulphur, most unpleasant and disgusting impressions on the sense of smell. So singular are the properties of matter, and so singularly are we constituted in reference to these properties.

8°. *Acrolein.*—When oil sugar (glycerine) is distilled in a retort over a quick fire, a liquid passes over, to which the name of acrolein has been given. This substance is volatile, possesses a strong penetrating peculiar odour, affecting almost immediately the nose and the eyes. Its vapour inflames the eyes, and if much breathed, and in a concentrated form, causes swooning, but without being poisonous.

This substance represents another large class of artificial bodies possessed of evil odours, which are produced by the destructive distillation, as it is called, of vegetable and animal substances. Coal tar, wood tar, coal and wood naphthas, the oils obtained by the distillation of horns, hoofs, fats, &c., are all examples of the varied and unpleasant-smelling products which are to be obtained by the process of dry or destructive distillation. They are all mixtures of several different substances, but the smells they severally possess are owing to the presence in each of them of one or more disagreeable compound bodies, of which it is unnecessary in this place to speak in detail.

It is unnecessary, indeed, to dwell longer on artificial substances which affect the sense of smell in an unpleasant

manner. Enough has been stated to satisfy the reader that the chemist can indeed prepare these bodies in far greater numbers than they are yet known to occur in nature, and with smells if possible still more insufferable.

VI. Smells produced by our manufactories.—In this great manufacturing country some of these artificial smells materially affect, at times, the comforts of common life. They have justly, therefore, been regarded as nuisances, and have given rise to disputes and contentions which not unfrequently occupy the attention of our courts of law.

From our manufactories of oil-of-vitriol (sulphuric acid) fumes of sulphurous acid, and even of sulphuric acid, are occasionally poured out into the surrounding air.

The makers of common soda (alkali-makers as they are called) still in some places discharge from their tall chimneys those vapours of muriatic acid which have so often blasted, not only the yearly crops, but permanent hedgerows and full-grown plantations.

The smelters of lead and copper vomit from their furnaces fumes of deadly arsenic, of zinc, of sulphurous acid, and even of lead itself, which sensibly affect both animal and vegetable life in their neighbourhood.

The soap and candle-makers dissipate into the air the volatile fetid substances which naturally exist in long-kept and rancid fats. As a result of some of these processes, also, they produce and send forth vapours of the irritating and unpleasant acrolein, to which reference was made in a preceding paragraph.

The distillation of wood for the manufacture of wood-vinegar—or pyroligneous acid, as it is called—is often attended by the emission into the surrounding air of disagreeable and unwholesome fumes.

The manufacturers of glass, even of plate and crystal

glass, when their operations are carelessly conducted, discharge from their cones unpleasant—it may be injurious—smells.

There is scarcely a manufactory, indeed, which involves the immediate application of chemical principles—and this includes by far the greatest number—which, if carelessly conducted, may not become a source of real annoyance, or even of injury to its neighbourhood. I speak from a very wide experience, however, when I say that the escape of injurious substances into the open air, from such works, is rarely necessary to the prosperity of the several branches of manufacture. For the comfort of common life, therefore, the intentional discharge of them into the atmosphere ought not to be permitted.

CHAPTER XXVIII.

THE SMELLS WE DISLIKE.

THE PREVENTION AND REMOVAL OF SMELLS.

Wide diffusion of evil odours.—Prevention of smells.—Decay prevented by freezing, by drying, by excluding the air, by salting, and by smoking.—Effects of charcoal.—Smell-disguisers or perfumes.—Smell-removers or deodorisers.—Charcoal; cause of its remarkable action.—Dr. Stenhouse's charcoal respirator; where it is likely to be useful.—Peat, vegetable soil, and burnt clay.—Smell destroyers or disinfectants.—Nitric oxide, sulphurous acid, muriatic acid, and chlorine gases.—The chlorides of lime, iron, and zinc.—Sulphate and pyrolignite of iron.—Iodine and iodoform.—Quicklime; its unlike action on fermenting and unfermenting matters.—Summary.

Evil odours are equally penetrating with sweet smells. They diffuse themselves through the air, and affect the senses unpleasantly, even when the absolute quantity of matter present is too minute to be detected by our most refined methods of chemical analysis. Unlike the sweet odours, however, they are produced everywhere around us, and are therefore a universal source of more or less perceptible irritation and annoyance. To prevent the introduction of evil-smelling substances into the atmosphere which surrounds us, and when present to remove them, has consequently been at all times an object of desire. The attainment of this object

has been rendered both more easy and more perfect by the discoveries of modern chemistry.

I. THE PREVENTION OF SMELLS. — The smells which usually arise from the decay or decomposition of the bodies and droppings of animals can often be either arrested or altogether prevented. Extreme cold, for example, such as is sufficient to freeze and harden the dead body of an animal, will preserve it in a state of absolute freshness, even for thousands of years. In northern winters the freezing of flesh and fish is the common way of preserving it; and in the ice cliffs on the banks of the Siberian rivers, the entire body of an extinct species of elephant has been met with, so little decayed as to be still greedily devoured by dogs. Even moderate cold, if accompained by a drying wind, will prevent decomposition, the former retarding the decay till the latter removes the moisture which is necessary to its continuance. Or the total exclusion of air will have the same effect, as is seen in the preserved meat, now so useful in long voyages and in remote parts of the earth.

These modes of preventing decay illustrate what has been said of the agency of heat, air, and moisture (p. 523), in promoting the putrescent fermentation of animal and vegetable substances. When we freeze them, we arrest decay by removing the necessary heat; when we dry them, by removing the necessary moisture; and when we shut them up in sealed vessels, by excluding the necessary air.

But decay can also be prevented by the direct application of chemical substances. Such is done when flesh meat is immersed in sugar, or when it is impregnated with common salt, or with a mixture of common salt and nitre. These substances fill the pores of the flesh, and thus preserve it by excluding the air. They form also, and especially the two

latter substances do, a species of chemical combination with the fibre of the meat, and with the substances contained in its natural juices, which are less liable to decay than the substances themselves, and thus retain the whole in a state of sweetness for an indefinite period.* Volatile tarry matters, such as creosote and others, which are contained in the smoke from peat and coal, in wood vinegar, and in the spirit which is distilled from coal or wood tars, act in a similar way. They combine with the fibre of flesh or fish, and retard its decay, until the removal of moisture by evaporation renders decay both slow and difficult. It is in this way that the smoking of fish or flesh contributes to a speedy *cure*, saving both time and salt, rendering the cure more certain, and adding at the same time an artificial flavour, which to many is very grateful.

Substances which thus retard decomposition are called *antiseptics.* Besides those I have mentioned, white arsenic, corrosive sublimate, the chloride of zinc, pyrolignite of iron, alcohol, camphor, and many essential oils, possess antiseptic virtues. In common life, however, these substances are rarely employed, though in museums of natural history alcohol is much used for bottling up anatomical and other preparations, and arsenic, corrosive sublimate, and camphor, for preserving insects and the skins of animals.

Charcoal, when recently burned, has much efficiency in preventing the offensiveness of animal decay from becoming sensible to the smell. Sprinkled in the state of powder over the parts of dead animals, it preserves them sweet for a length of time. Placed in pieces beneath the wings of a fowl, it keeps away much longer than usual any appearance of taint. Or if strewed over substances already tainted, or mixed with

* See The Beef we cook, p. 124.

liquids which have acquired the unpleasant smell of decaying organic matter, it removes the evil odour, and makes them sweet again. It is for this reason that pieces of fresh charcoal are now and then introduced into our common water-filters.

In all these cases, charcoal appears to act rather as a smell-remover than as a decay and smell preventer. In what way it acts as a remover of smells will be explained in a future part of the present chapter.

Quicklime also possesses the property of retarding, and to a certain extent preventing, the decay of animal and vegetable substances. Its action, however, as we commonly use it, is of a complicated kind, and will be explained when we come to treat of the smell-destroyers.

II. The Disguising of Smells.—Where evil-smelling decay of any kind commences, or where volatile substances which disagreeably affect the organ of smell escape into the air from any source, we naturally desire to rid ourselves of the unpleasant sensation. This we generally wish, and always ought if possible to do, by removing the substance to which the noisome smell is owing. In the great majority of cases, however, we merely overpower or disguise it. We are content to mingle with the smell we dislike some odour we can enjoy, and to leave floating in the air around us the evil and the good together, to produce unheeded their natural effects upon the system.

Sweet odours are thus the natural disguisers of evil smells. They are the only resource of rude and dirty times against the offensive emanations from decaying animal and vegetable substances, from undrained and untidy dwellings, from unclean clothes, from ill-washed skins, and from ill-used stomachs. The scented handkerchief in these circumstances takes the place of the sponge and the shower-

bath; the pastile hides the want of ventilation; the attar of roses seems to render the scavenger unnecessary, and a sprinkling of musk sets all other stinks and smells at defiance. The "sixty stinks of Cologne" may thus be at once the parent and grand consumer of its artificial rivers of scented water. The fiercest demand for the luxury of civilised perfumes may exist where the disregard of healthy cleanliness is the greatest. Even the burning of incense at the altar may find a merely rational use in disguising the dank and unwholesome smells which damp floors and walls engender, and in hiding from the senses of the worshipper the noxious effluvia which slowly-decaying bodies in hidden vaults are continually giving off.

However much, therefore, the employment of fragrant essences may add to the comfort of the cleanly and refined, they may only promote disease and discomfort among the ignorant and barbarous, by concealing the deadly malaria, or overpowering the noisome stench.

III. The Removal of Smells.—The absolute removal from the air—at least from any limited portion of it—of the greater number of the evil smells I have described, is, however, by no means a difficult task: the substances by which this is effected are known in modern sanitary language by the name of *deodorisers*.

1°. *Charcoal.*—Of these deodorisers, or smell-removers, charcoal, in its various forms, is one of the cheapest, most abundant, and most efficacious. I have already spoken of this substance among the preventers of smells as being an apparent retarder of putrefaction. That it is so, however, is doubtful. Many regard it, on the contrary, as a hastener of decay; but as a remover of smells, its action and virtue are undoubted. Mixed with fermenting night-soil, or with the contents of our common sewers, it sweetens them almost

immediately, and it produces a like effect upon almost every variety of decaying animal and vegetable matter. Spread to a depth of two or three inches over a festering grave-yard, or even over a decaying dead body, it is said to prevent any evil odours from rising into the air, or becoming sensible to the smell.

Animal charcoal—such as is produced by the charring of animal substances—peat charcoal, and the black powder obtained by charring together a mixture of earth and vegetable matter, are more efficient in this removal of smells than common wood-charcoal, however finely it may be powdered. It is this power of absorbing evil odours which has recently recommended peat charcoal so strongly to the sanitarian for removing the smells of grave-yards, cesspools, drains, and other places where filth has been permitted to accumulate, and has induced the farmer in many places to employ it in absorbing the valuable liquids which escape from his stables and fold-yards.

This remarkable action of charcoal is the result of three properties, the influence of each of which it is important to distinguish. These are—

a. Its remarkable porosity. In consequence of this, it absorbs gaseous substances in large quantity, and condenses them in its pores. A cubic inch of light wood-charcoal will absorb nearly 100 cubic inches of gaseous ammonia, between 50 and 60 of sulphuretted hydrogen, nearly 10 of oxygen, and lesser proportions of other gases. This property is for the most part physical, and is possessed in a considerable degree by other porous substances.

b. The special affinity which charcoal exhibits for certain strong-smelling and colouring substances. So powerful is this affinity, that if a table-spoonful of finely-powdered animal charcoal—or twice as much of newly-burned wood-charcoal—be shaken up with a pint of stinking ditch-water, and the

mixture filtered, the water will pass through bright, clear, and with little of either taste or smell. If, instead of dirty water, we take porter or port wine, smell, taste, and colour will in like manner disappear. This property is almost purely chemical.

c. The oxidising influence it appears to exercise upon the substances it absorbs. These substances, whether gaseous or solid, whether strongly smelling or strongly colouring, as soon as they are laid hold of by the charcoal, begin to unite with oxygen, to lose their characteristic properties, and to change into new chemical compounds. Ammonia, for example, changes into nitric acid, sulphuretted hydrogen and sulphurous acid into sulphuric acid, and so on. This action is purely chemical. But the charcoal does not *pro*duce, it only *in*duces it. It condenses these gases within its pores, and when brought in contact in this condensed state, they act upon each other so as to produce nitric or sulphuric acids.* In like manner, solid substances change, and the smell-removing influence of charcoal ceases when its pores become filled with the new and fully oxidised compound thus produced.

I have said that it is doubtful if charcoal, though it keep fresh meat sweet, really does preserve it from decay. It is in consequence of the oxidising influence just described that many regard it as in reality hastening the decay of

* Thus, N being nitrogen, H hydrogen, and O oxygen—

	N.	H.	O.			N.	H.	O.
1 of ammonia unites with	1	3	–	to form	1 of nitric acid and	1	–	5
8 of oxygen,	–	–	8		3 of water,	–	3	3
Sum,	1	3	8		Sum,	1	3	8

and S representing sulphur—

	S.	H.	O.			S.	H.	O.
1 of sulph. hydrogen unites with	1	1	–	to form	1 of sulphuric acid and	1	–	3
4 of oxygen,	–	–	4		1 of water,	–	1	1
Sum,	1	1	4		Sum,	1	1	4

animal bodies. This may well be, but decisive experiments are still wanting.

Dr. Stenhouse has recently availed himself of the absorbent property of charcoal in the construction of a respirator, which, as a remover of noxious vapours and unwholesome smells from the air we breathe, promises to become a sanitary instrument of great value. This respirator (figs. 96 and 97) consists essentially of a hollow case made of fine

Fig. 96.

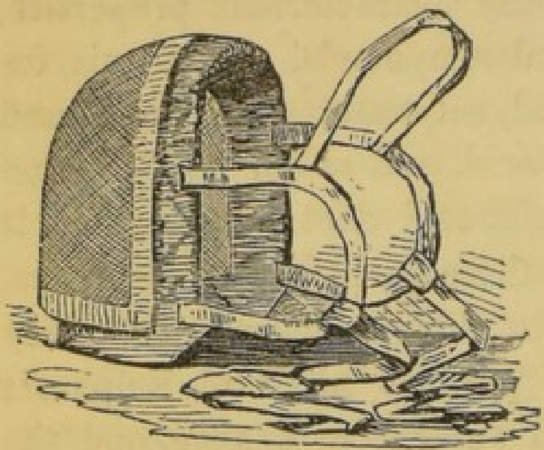
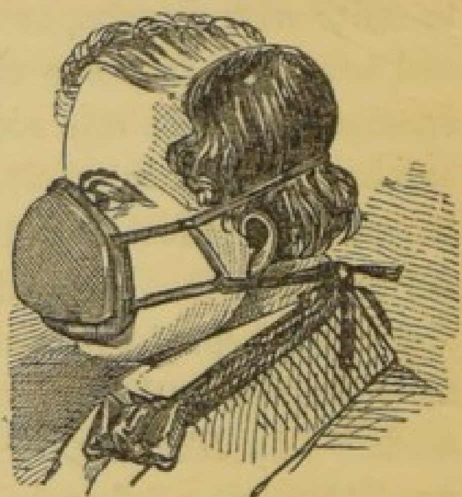


Fig. 97.



flexible wire-gauze. Internally it is about half an inch wide, and of sufficient length and breath, when folded over the lower part of the face, to cover closely either the mouth alone or both the mouth and the lower part of the nose. The hollow space is filled with coarsely powdered charcoal, and the instrument, like the common metallic respirator, is fitted to the face, and fastened over the head by attachments of ribbon. Through this powdered charcoal the breathing is effected. All the air that enters the lungs must pass through this charcoal sieve, and in so passing is deprived of the noxious vapours or gases it may contain. Whether, as in the case of cesspools, laboratories, hospitals, dissecting-rooms, and the holds of ships, these vapours be perceptible and offensive to the smell; or whether, like the miasms and malaria which marshes and festering ponds exhale, they be

imperceptible to the senses; still the charcoal, it is alleged, will arrest them, and thus secure the wearer of the respirator from their irritating and unwholesome influences. After a while the charcoal powder becomes saturated, or too old to act with efficiency; but an ounce of powdered wood-charcoal renews it, or the old charcoal heated to redness in a close vessel, and the instrument is itself again.

To a certain extent there is no doubt that this charcoal respirator will produce the effects anticipated from it, and its little cost and easy construction are great recommendations to it. It has already found its way into hospitals, sick rooms, chemical manufactories, and many laboratories. It is also one of those cheap applications of scientific discovery to which the least regarded of our labouring population, the humble gravedigger, the despised sewer-cleaner, and the Irish drudge in our filthiest factories, may owe hereafter hours of happy health and painless sleep. And should it powers in arresting unperceived malaria be established by experience, how important will it become to the traveller in unwholesome marshy regions, like those along the foot of the Himalayas, those which skirt the lower course of the Niger and the Mississippi, or such as spread over south European flats and valleys, like the Pontine and other Italian marshes, and the Dobrudscha towards the mouth of the Danube. May it not even prove a safeguard and health-preserver in many of those inhabited parts of the world where rich crops are dearly bought at the expense of rarely absent fevers, aguish fears and tremblings, debilitated frames, and short, unhappy lives?

2°. *Peat, Vegetable Soil, and Burned Clay.*—Peat, if dry and in powder, acts also as an absorber of smells. It is likewise of an acid nature, which enables it to combine with and thus to retain many of the stinking substances it has absorbed. Earth rich in vegetable matter acts in a similar

manner, and even some varieties of clay purify the water that filters through them. The porous mass obtained by burning together clay and vegetable matter under cover has also, as I have already remarked, a powerfully absorbent property; and the coal cinders we throw into our ash-pits, by their porousness retain a portion of the effluvia which escape from the other offal with which they are mixed, and thus lessen their offensiveness.

It is a valuable property of charcoal, cinders, peat, earth and clay, burned or unburned—when saturated with ill-smelling substances, such as those I have mentioned—that, when conveyed to the land, they fertilise the soil among which they are mixed, and gradually yield, as valuable nourishment to growing plants, the disagreeable forms of decaying matter which they had previously absorbed or taken up.

IV. The Destruction of Smells.—Substances that absorb and remove evil-smelling bodies do not necessarily destroy their smells, or take away any poisonous quality they may possess. Thus water absorbs sulphuretted hydrogen, but acquires, at the same time, its offensive smell and its poisonous property. Heat the impregnated water, and the gas escapes again into the air with all its original qualities. Bodies which act, as water does in this case, remove, but do not change, the smelling substance.

But if into water or air which smells of sulphuretted hydrogen a little chlorine gas be introduced, the smell of rotten eggs will disappear almost instantaneously. The sulphuretted hydrogen is decomposed and destroyed. It no longer exists, and consequently both its smell and poisonous influences are gone.

Water, as regards sulphuretted hydrogen, is a smell-remover or *deodoriser*. Chlorine acts upon the same substance as a smell-and-poison destroyer, or *disinfectant*.

This distinction is not without its practical importance. Water, soil, and other absorbents, may remove and retain noxious substances so long as cold or wet weather continues; but let heat and drought return, and forthwith from water and soil they steam up again more or less unchanged. Hence those reeking miasms which spread mortal fever and chattering ague over entire provinces. The disinfectant decomposes and destroys the evil compound, so that no change of circumstances can bring it into activity again.

All disinfectants act chemically. They either decompose or they combine with the noxious substances and produce new compounds, which, if not always void of smell, are comparatively harmless in their action upon the human body. I shall mention those which are at once most efficacious and most easily accessible.

1°. *Nitric Oxide Gas* is produced when the common aquafortis of the shops is poured over pieces of copper in a glass or earthenware vessel. As it rises into the air it combines with oxygen, and forms red fumes of a strongly acid nature (nitrous acid), which diffuse themselves through the atmosphere. These fumes are capable, it is believed, of destroying nearly all the noxious and offensive matters, whether of mineral or organic origin, with which the air is likely to be contaminated. The objections to their use are, that they provoke cough, and cannot be breathed with safety; that they corrode nearly all metallic substances with which they come in contact; and that their chemical action upon the noxious bodies they are expected to remove is neither well understood, nor, where the fumes are in a very diluted state, by any means certain.

2°. *Sulphurous Acid Gas* is produced when sulphur is burned in the air. It is one of the offensive substances I have described among mineral smells. In large quantity, it is both noxious and offensive to breathe, but as a disinfectant

it may often be used with advantage. Hence the very common practice of fumigating with burning sulphur.

The first effect of this gas, when diffused through the air, is to overpower all other smells, and thus to make them imperceptible: it acts as a smell-disguiser. Its next effect is chemically to decompose or destroy such offensive substances as the sulphuretted and phosphuretted hydrogens of which mention has been so frequently made; and as it is of a strongly acid nature, it as speedily combines with alkaline vapours—such as those which contain ammonia, or the evil-smelling body which gives its odour to stinking fish (p. 517) and removes their smells. It exercises also a special action upon many organic substances. This may be seen by holding a burning sulphur match beneath a red rose, which it generally whitens, and by the change of colour it produces upon many other flowers. It is also seen in the common use of the fumes of burning sulphur for bleaching silk and woollen goods, and for whitening the straw employed for ladies' bonnets. It is believed, therefore, to be capable also of destroying any noxious substances of organic origin which may happen to be present in the air with which it mingles.

On the whole, sulphurous acid has much to recommend it. It is also cheap and universally accessible. The objections to the use of the gas are, that it is itself unpleasant and repulsive—that when employed for disinfecting purposes, the inhabitants of a house must be excluded till the operation is concluded and the apartments fully ventilated—that it corrodes metallic surfaces, and leaves behind it for some time traces of its own disagreeable smell.

3°. *Muriatic Acid Gas* is produced when the oil of vitriol of the shops (sulphuric acid) is poured upon common salt. It unites with the moisture of the air the moment it is disengaged, and forms white, strongly acid fumes, which provoke cough and cannot be breathed. These acid vapours

will undoubtedly act upon and destroy many kinds of strong-smelling and noxious gases and vapours which may be present in the air. The objections to its use, however, are the same as those against the use of nitric oxide, and of nearly equal strength.

4°. *Chlorine Gas* is obtained when the common spirit of salt (muriatic acid) of the shops is poured upon finely-powdered black oxide of manganese; or when this powdered oxide is mixed with the common salt before pouring oil of vitriol upon it, as in the preparation of muriatic acid gas, above described.

Chlorine is a heavy, greenish coloured, suffocating, and strongly-smelling gas. In a dilute state, its smell is now familiar to most persons as that given off by the common chloride of lime of the shops.

This gas decomposes sulphuretted hydrogen, phosphuretted hydrogen, ammonia, and nearly all the other gaseous compounds and evil-smelling vapours which escape from decomposing animal and vegetable matters. It acts, indeed, upon all organic substances almost without exception. Hence its extensive use for bleaching cotton, linen, fatty bodies, and a host of other vegetable productions used in the arts.

Chlorine has been long employed as a remover and de stroyer of unpleasant smells. It is probably the most generally efficient for this purpose of any gaseous substance with which we are acquainted. And besides its efficiency, it is further recommended by being easily and cheaply prepared; by producing its good effects even when diluted with much air; and by being breathable, when so diluted, without injurious effects. It can thus be used within a building without displacing its inhabitants, and with little inconvenience even in the chambers of delicate invalids. In this dilute state, also, its use is free from almost every other objection. For though it does corrode metallic substances, its evil effects in

this way are much less sensible than those of any of the other gases already mentioned.

The use of these gaseous substances is restricted almost entirely to the removal from the air of evil-smelling and noxious substances which are already mixed with it. But a service often demanded of disinfectants, and one not less important for sanitary objects, is, to prevent the emission of these substances into the air altogether—to arrest, confine, and fix them down among the festering substances which produce them. This service can only be rendered by bodies which are in the solid or liquid state, and can therefore be mixed or spread over the decaying matters from which the hurtful emanations proceed.

A satisfactory disinfectant of this kind must also possess at least two well-marked chemical properties. These are distinctly pointed out by the general chemical characters of the evil-smelling substances to be acted upon.

These substances, as they arise from decaying vegetable and animal bodies, are, for the most part, of two chemical kinds. They are either alkaline substances, like ammonia and trimethylamine (p. 517), or they are acid substances, like the sulphuretted and phosphuretted hydrogens. An effective disinfectant must be able either to decompose or to combine with *both* of these classes of compound bodies. And economically, its value will be further increased, if, while it effects these chemical purposes, it at the same time produces a new substance which is not offensive in any way; and still more if it produces one that is positively useful.

5°. *Chloride of Lime* possesses the chemical qualities of an efficient disinfectant in a high degree. It consists of lime and chlorine: of these, the lime combines with all the acid bodies represented by the sulphuretted hydrogen, while the chlorine either combines with or decomposes the alkaline compounds represented by ammonia. It is therefore gener-

ally and deservedly esteemed as one of the best, most efficient, and most manageable of our solid disinfectants. Spread in the solid form upon any fermenting mass, it destroys the noxious bodies as they are formed. Dissolved in water, and sprinkled over bad-smelling chambers, or mixed with more or less fluid collections of putrid matter, it brings sweetness everywhere. Fetid odours and poisonous qualities alike disappear before it. Only its comparatively high price prevents its being employed for sweetening our common sewers, garbage-heaps, and cesspools.

The results of its action have the further advantage, that they are not offensive either to sight or smell; but they do not possess the same fertilising richness as the mixed heaps obtained by the use of powdered charcoal. Its chlorine decomposes ammonia, and hence fermenting heaps treated with chloride of lime will be poorer in this ingredient so valuable to vegetation.

6°. *The Chlorides of Iron and Zinc*, especially when made somewhat acid, are, chemically speaking, almost equally efficacious. They have the disadvantage, however, that they run to liquid (deliquesce) rapidly, when exposed to the air, and cannot well be preserved in the solid form. Hence they are generally dissolved in water, and used in the liquid state.

It is an objection to the liquid chloride of iron that it causes a brown stain wherever it is spilt, and makes the fermenting substances to which it is applied of a black colour. The zinc liquid is itself colourless, colours nothing when it is spilled, and when poured upon the foulest decaying substances, only covers them with a white cream. These properties cause it to be preferred to the iron liquid, where economy is not an object, the chloride of zinc being the more costly of the two.

The solution of chloride of zinc forms what we frequent-

ly see advertised under the name of "Burnet's Disinfecting Fluid." It has the property of not only deodorising and disinfecting, but of actually preventing decay, especially in vegetable substances. Hence, like corrosive sublimate and pyrolignite of iron, it has been extensively used for saturating timber, especially such as is to be used in circumstances in which timber is liable to rot.

7°. *Sulphate of Iron*, or common green vitriol, is equal in efficacy to the chloride of iron, but, except that it does not run to a liquid, is liable to the same objections. It is much used in parts of Switzerland and other countries, for removing the smell and fixing the volatile ingredients of fermenting dung-heaps and liquid-manure tanks.

8°. *Pyrolignite of Iron*, prepared by dissolving iron in impure wood-vinegar, is equal in immediate efficiency to either of the preparations of iron above mentioned. To some, however, the smell which this solution occasionally possesses is an additional objection to the use of it.

9°. *Iodine*, and one of its compounds known to chemists by the name of iodoform, have recently been recommended as smell-removers and disinfectants; but however efficient, their expense must always exclude them from anything like extensive use.

10°. *Quicklime*, though so abundantly used during the cleansings to which the cholera-visitations have given rise, is less efficacious either as a remover or a destroyer of smells than any of the substances above mentioned. It is usually employed in the state of newly-slaked lime. In this state its action on animal and vegetable substances is twofold.

a. If the substance be fresh, it retards and partially prevents its decay. This is its effect upon flesh, blood, recent animal droppings, nightsoil, urine, &c. And as decay afterwards slowly comes on, it modifies the nature of the chemical substances produced, so that ammoniacal and other strong-

smelling compounds do not arise from them, or at least not so sensibly as would otherwise have been the case. To *fresh* animal matters, therefore, quicklime, as a preventer of smells, is a very proper addition.

b. But if the substance have already begun to ferment, the lime acts very differently. It is strongly alkaline, and therefore while it combines with the acid substances which the fermented matter may contain, it sets free the ammonia and other volatile strong-smelling alkaline compounds which may have been formed in it. Thus its first effect, when laid upon fermenting animal and vegetable refuse, is to increase the quantity of odoriferous matter which exhales, and consequently the intensity of the smell. Its next effect is to retard further decomposition, to induce, as charcoal does, the decaying matter to form nitric and sulphuric acids, and thus so to change the chemical nature of what does afterwards rise into the air, as to make it both less disagreeable to the smell, and less injurious to the health.

Spread in a layer over a foul heap, therefore, it disengages a great amount of strong-smelling volatile matter; but this being once carried off by the wind, the covered heap remains comparatively quiescent. The lime arrests and unites with the sulphur and phosphorus as they approach the surface of the heap, and disposes the substances containing nitrogen to change into nitric acid, and combine with itself, instead of dissipating themselves into the air in the form of ammonia and other volatile alkalis. With the exception of the first loss it occasions when laid on fermented matter, therefore, lime retains in the decaying heap the greater part of wha makes it of value to the farmer.

It is in close and confined places, where the wind has not ready access to sweep away what is at first evolved, and to masses of putrid semi-fluid matter, such as collections of nightsoil, that the application of quicklime may prove most

unpleasant. When used in such circumstances, it should be strewed on lightly, or after the heap has been spread over with straw, peat, sawdust, or other similar substance; and the mass should, if possible, be entirely covered over with it, and left afterwards undisturbed.

On the whole, when the *air only* is to be sweetened and rendered wholesome, the safest, cheapest, and most effectual destroyers of smells, are chlorine gas and chloride of lime. A simple way of applying this gas for individual use is to moisten a linen cloth with vinegar, and sprinkle over it finely-powdered chloride of lime. Air breathed through this will enter the mouth charged with a minute quantity of chlorine, which will effectually destroy any noxious vapours and miasms that escape from diseased bodies, or from decaying animal and vegetable substances. These prepared layers of cloth may be introduced in place of the charcoal into Dr. Stenhouse's respirator, and worn over the mouth. The healthy man so protected may without fear visit the chambers of the sick, and the sanitary officer without risk venture into the most dangerous receptacles of filth. Breathing in by the mouth, and breathing out by the nose, the air in his lungs would be always pure and wholesome.

Where water-closets, cesspools, or heaps of fermenting matter are to be freed from smell, chloride of lime is probably still the best agent. But chloride of zinc and sulphate of iron are both perfectly efficient, and both to be bought in the shops. Any of the three, therefore, may be used indifferently, according to the taste and convenience of the user

But when large operations are to be carried on, as in the sanitary cleansing of towns, charcoal powder, the smother-burned mixture of clay and vegetable matter, and quicklime, are the cheapest and most available. The two former are excellent and unexceptionable; the latter has the disadvantage, that from substances already fermenting it drives out

for a while more powerful odours than they naturally emit, and requires, therefore, to be used with care and caution. In their chemical influence upon the after decay of the substances to which they are applied, charcoal and quicklime, as I have said, resemble each other very much.

For the sake of clearness, I may briefly recapitulate the several classes of substances I have endeavoured to classify and distinguish in the present chapter. These are

1°. *Decay-Preventers, or Antiseptics*, including common salt, saltpetre, white arsenic, corrosive sublimate, the chlorides of zinc and iron, pyrolignite of iron, sugar, creosote, alcohol, camphor, the essential oils, and in certain cases quicklime. Only a few of these are adapted for sanitary use.

2°. *Smell-Disguisers, or Perfumes.*—To this class belong the greater part of the substances already described among the odours we enjoy.

3°. *Smell-Removers, or Deodorisers.* — Among these, charcoal, peat, fresh and charred, clay burned, unburned, or smother-burned along with vegetable matter, and other porous substances, are the most important.

4°. *Smell-Destroyers, or Disinfectants*, which not only absorb and remove evil smells, but decompose and change, and thus altogether remove the substances which produce them. To this class belong nitric oxide, muriatic acid, sulphurous acid, chlorine, the chlorides of lime, zinc, and iron, the sulphate and pyrolignite of iron, iodine, iodoform, and quicklime.

To disinfect, a substance must chemically change the noxious compound and produce a harmless one. All chemical change does not involve the latter result, as some poisonous vapours may be chemically changed, and remain poisonous still. Such is the case with those of kakodyle and the

cyanide of kakodyle, described in a previous chapter (p. 532). But all the disinfectants described and recommended in the preceding pages, are really poison-destructive as regards all *natural* evil smells and miasms with which we are yet acquainted.

NOTES TO ODOURS AND SMELLS.

1°. *Chap. XXV.*—In my concluding remarks upon sweet odours (p. 502), I have drawn the attention of the reader to the inconceivably minute quantities of odoriferous matter which make themselves sensible in the air. I have since found, in Dr. CARPENTER'S *Comparative Physiology*, that "a grain of musk has been kept freely exposed to the air of a room, of which the door and windows were constantly open, for a period of ten years; during all which time the air, though constantly changed, was completely impregnated with the odour of musk; and yet at the end of that time the particle was found not to have sensibly diminished in weight!" Can anything illustrate more strikingly the very trifling quantities of foreign matter in the air by which sensible effects, whether for good or for evil, may be produced upon us?

2°. *Chap. XXVII.*—Since this chapter was published, i has been announced that the substance *propylamine*, mentioned in p. 517 (note), as having the smell of stinking fish, has been found in the flowers of *Cratægus oxyacantha* (common hawthorn), *Cratægus monogyna ;* also in those of *Pyrus communis* (the pear-tree), and *Sorbus aucuparia.* The odour of these flowers has often been thought to resemble that of decaying fish.

3°. In page 531 I have said that other *Kakodyles* might be formed besides the one there described; and this has in fact already been discovered—the combination of arsenic with *Ethyle.* Like the compound already known, it has a peculiarly insufferable smell, and takes fire in the air. It offers us another material for asphyxiating shells.

CHAPTER XXIX.

WHAT WE BREATHE AND BREATHE FOR.

What is it to breathe?—Structure of the lungs.—Quantity of air inhaled.—Breathing by the skin.—Structure of the skin.—Effect of breathing on the composition of the air.—It increases the proportion of moisture and carbonic acid, and diminishes that of oxygen.—To what extent it does so.—Quantity of carbonic acid given off from the lungs and the skin.—Purpose for which man breathes.—The oxygen absorbed helps to form the substance of the muscular and other tissues.—It converts the waste material of the body into urea and other soluble substances preparatory to its removal.—It converts the fat and starch of the food into carbonic acid and water.—Acts in a similar way upon alcohol.—Why the carbonic acid from the lungs varies in quantity.—Physiological effect of these chemical changes.—They are the chief source of animal heat.—Minor sources of this heat.—Careful provision for the constant disengagement of this heat.—Purposes served in external nature by the breathing of animals.

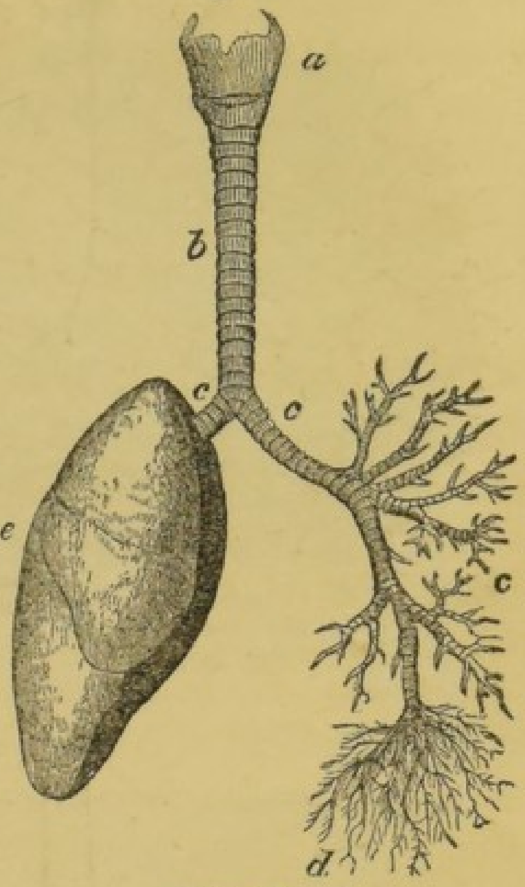
I. What is it to breathe?

1°. To breathe, in the usual acceptation of the term, is to draw in atmospheric air through the mouth and nose into the lungs, and after a brief interval to throw it out again.

The lungs into which the air is thus drawn, consist of two rounded oblong, somewhat flattened, masses of very cellular substance, situated in the cavity of the chest, and communicating with the atmosphere through the wind-pipe, or trachea. The general form of the human lung is repre sented in the annexed figure.

The air or wind pipe (*a b* fig. 98), as it descends from the throat, branches off into large (bronchial) tubes (*c c*); and these again and again into smaller, still smaller, and finally into hairlike vessels (*d*). Through these the air penetrates into the remotest parts of the cellular substance. Around each *visible* extremity nearly eighteen thousand cells are clustered (17,790, Rouchoux), each of which is connected through these minute tubes with the external air. The cells vary in size; they have a diameter of from one-seventieth to one two-hundredth, or, on an average, of about one-hundredth of an inch. The total number of them is reckoned at six hundred millions! Their walls are very thin; they are mere air-vesicles.

Fig. 98.



Human Lung.

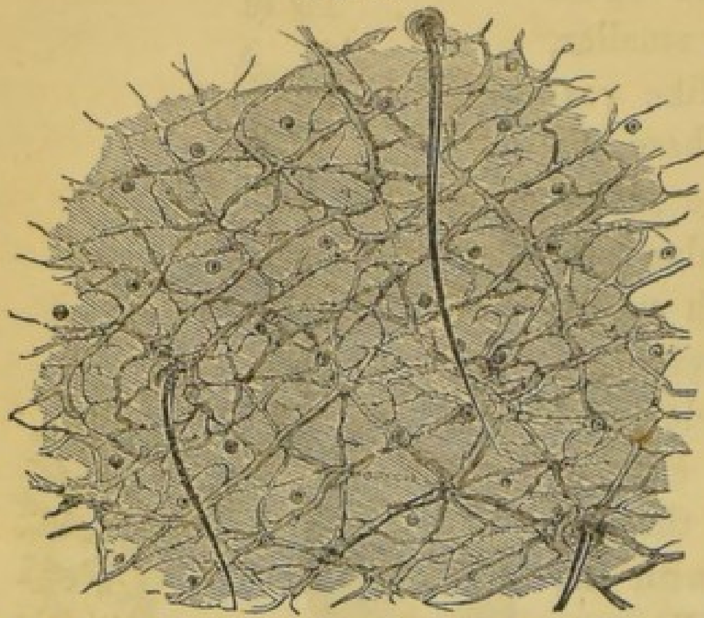
a the larynx; *b* windpipe; *c c c* bronchial tubes or air passages; *e* lung.

The lungs, as this structure implies, are very elastic, and consequently the volume of air they contain very variable. The average quantity which, by an effort, the lungs of an adult can be made to inhale, is from five to seven pints; and the quantity they draw in at an ordinary, natural, but full inspiration, *may* be as much as two pints and a half; an ordinary tranquil respiration, made without effort, takes in only about one pint.

At the easy average of eighteen inspirations a minute, this makes the bulk of air drawn in and thrown out again to amount—in common life—to about eighteen pints

a minute, a thousand pints an hour, or three thousand gallons a-day. Some estimate it as high as four thousand gallons a-day for an average man in average circumstances, and as high as five thousand seven hundred gallons a-day for an athletic man undergoing severe exertion.

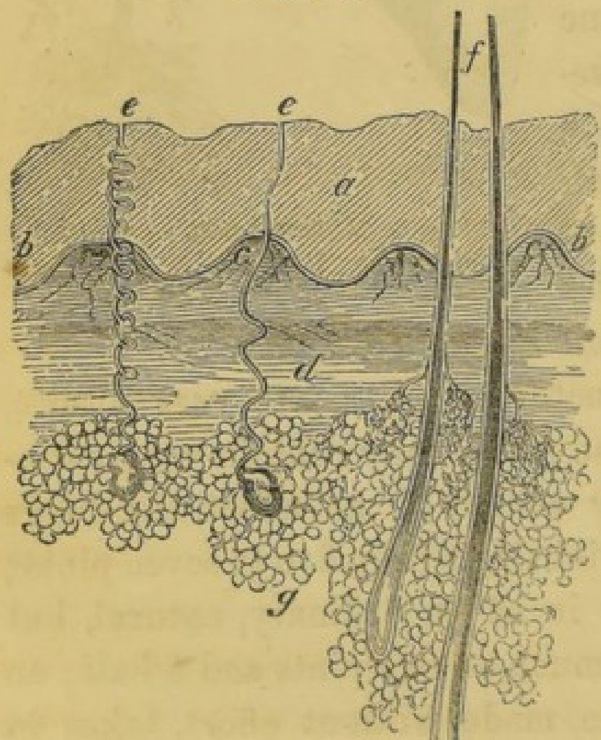
Fig. 99.



Surface of the Cuticle greatly magnified, showing the pores and hairs.

2°. But this lung-work forms only part of the operation of breathing; we breathe also through the skin. The cuticle or outer skin of most animals is perforated by numerous pores (fig. 99). These pores are the outlets of minute spiral vessels which penetrate through the skin into the cellular substance beneath (fig. 100, *g*). In the human cuticle, the pores are more numerous in some parts of the body than in others, but the outer skin of a full-grown man is sprinkled over with about seven millions of them, while the united length of the spiral

Fig. 100.



Vertical section of the skin, greatly magnified.

a the cuticle, outer, or scarf skin; *b d* the true skin; *c* censory papillæ; *e* sweat glands and their ducts, the outlets at the surface being the pores; *f* hairs; *g* cellular substance.

vessels connected with them is reckoned at twenty-eight miles! Through these vessels we pour out constantly the solid and fluid substances which form our visible perspiration. But through them also air enters and escapes continually, in a healthy state of the body, as it does from the air-vessels of the lungs. And though the total quantity of this kind of work done by the skin is very much less than that which is performed by the lungs, yet it is both material in amount, and of essential importance to the general health of the body.

The air we draw into our lungs is thrown out again after a brief interval. That which enters by the skin probably remains longer. What change does this air undergo during its short visit to the interior of the body?

Three distinct and sensible chemical alterations are produced by the breathing animal upon the air which enters and surrounds it.

First. If the breath of an animal, as it escapes from the mouth, be received in a dry cool vessel, or upon a clean mirror, the surface of either will be rendered dim by a thin coating of moisture. In like manner, if the naked hand or arm be enclosed in a clean dry glass vessel, a deposit of dew will gradually be formed upon its inner surface. Both from the lungs, therefore, and from the skin, watery vapour is continually, though insensibly, given off into the surrounding atmosphere. As it comes out, the air contains more moisture than when it went into the body. This is the first change.

Second. It is a property of carbonic acid gas that, when passed through lime-water, it speedily renders the liquid milky (p. 8).

Now, if we put a quantity of lime-water into a close bottle, and draw common atmospheric air through it, as in the annexed figure (fig. 101), we shall see that for a *long*

time the water will remain bright and transparent. A very large volume of air must be drawn through before the

Fig. 101.

clearness of the water sensibly diminishes, and still more before it becomes perceptibly milky. This shows that though carbonic acid is present in the air, it is so only in very small proportions.

But if, instead of *drawing* atmospheric air through the lime-water, we *blow* through it the air which comes from the lungs, as in figure 102, we shall see the bright clearness of the liquor disappear almost immediately. In a very few minutes it will have become opaque and milky. The air, as it comes from the lungs, contains, therefore, more carbonic acid than as it went in. This is the second change.

Fig. 102.

In like manner, if any part of the naked body be surrounded for a while by a close vessel, and the air within the vessel be subsequently examined, a larger proportion of carbonic acid will be found in it than is usually present in an equal bulk of the surrounding atmosphere. Thus, from our lungs and from our skin we are continually, though insensibly, breathing out carbonic acid, and adding to the proportion of this gas which naturally exists in the air in which we live.

Third. If either the air which comes from our lungs, or that in which a naked limb has been for some time closely confined, be chemically examined, it will be found to contain a smaller per-centage of oxygen than is present in common atmospheric air. The lungs and skin, therefore, are continually drinking in oxygen from the air. This is the third change.

Thus the three chemical alterations which atmospheric

air undergoes through the agency of the breathing animal are — that it is rendered moister than before — that the proportion of carbonic acid is increased—and that the percentage of oxygen is diminished.

3°. To what extent do these changes take place? Can we estimate it in numbers?

a. The quantity of water which is thrown out into the air from the lungs of a healthy man is very variable. It is modified by climate, by individual constitution and state of health, by the amount of exercise taken, by the quality of the food, by the quantity of liquid consumed, and by a variety of other circumstances. Generally speaking, however, the quantity given off from the lungs and skin together is equal to about one-third of the weight of the whole food, solid and liquid, which is taken into the stomach.

Now the skin alone of a full-grown man exhales in twenty-four hours, and in ordinary circumstances, from one and a half to two pounds of water in the state of insensible perspiration. The difference between this weight and that of one-third of the whole food, solid and liquid, represents the quantity of water daily discharged from the lungs. It is not far from the truth to say that, for every pound and a half discharged from the skin, about one pound is given off from the lungs.

b. We have already seen that the air we breathe contains, in its natural state and at ordinary elevations, about two gallons of carbonic acid gas in every five thousand of air, (p. 9). This is its condition as it enters the lungs. As it returns it contains on an average three and a half gallons in every hundred! In cases of disease the proportion of carbonic acid sometimes mounts up to as much as seven gallons in a hundred. The quantity of this gas discharged from the lungs, therefore, in twenty-four hours, must be very considerable.

Like that of watery vapour, this quantity varies with many circumstances. Size, age, sex, food, climate, constitution, health, exercise, all modify it. In a full-grown man the weight of carbonic acid given off varies from one to three pounds in twenty-four hours.

This gas contains in every hundred pounds twenty-eight pounds of carbon (pure charcoal) and seventy-two pounds of oxygen. Hence the weight of carbon which escapes in this form from the lungs of a full-grown man varies from five to fifteen ounces in the twenty-four hours.

The quantity given off from the skin varies from a thirtieth to a ninetieth of that which escapes from the lungs. In man it probably averages about one-sixtieth. This is equal to fifty or sixty grains of carbon in the twenty-four hours. Bodily exercise greatly increases this quantity, as it does that of watery vapour. The human skin, when a person is in motion, perspires three times as much as when he is at rest. The skin of a horse, when put to the trot, gives off one hundred and seventy times as much as when it is at rest—(GERLACH).

c. The proportion of oxygen gas which atmospheric air contains is very nearly twenty-one gallons in every hundred. After it has visited the human lungs, however, this proportion is reduced to sixteen or eighteen in a hundred, and sometimes lower. The lungs extract from one-seventh to one-fifth of its oxygen. The absolute weight of the oxygen thus taken up in a day also varies with many circumstances. It is generally equal to about one-fourth of the weight of the whole food, solid and liquid, which an animal consumes. But whatever increases the quantity of carbonic acid given off, generally increases, and nearly in an equal degree, that of the oxygen absorbed.

As regards this absorption of oxygen gas, the skin acts somewhat differently from the lungs. Both absorb oxygen,

as both give off carbonic acid. But while the bulk of oxygen taken in by the lungs somewhat exceeds that of the carbonic acid given off, the opposite is the case with the skin. It gives off a considerably larger bulk of carbonic acid than it drinks in of oxygen gas.

Such is this most vital process of respiration, considered in itself; and such is the chemical influence in kind and quantity which a full-grown man by his breathing insensibly exercises over the composition of the atmosphere which surrounds him.

But for what end does man breathe? What good follows to himself, or what useful purpose is served in external nature, by the changes which his breathing produces upon the air in which he lives? These questions we must consider in their order.

II. For what good to himself does man breathe?

To obtain a clear answer to this question we must examine the function of respiration more closely.

The oxygen which enters into the circulation of the body through the lung-surface is equal in weight, as we have seen, to one-fourth of all the solids and liquids introduced into the stomach. It considerably exceeds in weight that of the dry solid food taken alone. This oxygen is the main source of the good which man derives from breathing. This good is partly direct and chemical, and partly indirect and physiological. If we follow the oxygen in its course through the body, we shall see how it benefits the breather both chemically and physiologically.

1°. *The direct and chemical good* includes several different operations, which, for the sake of clearness, it is necessary to distinguish.

First. The oxygen enters the cells of the lungs, and is

absorbed by the minute vessels which spread over the cell walls. Within these vessels it combines directly with certain constituents of the flowing blood, and proceeds with it in its ceaseless current through the arteries and veins.

The first purpose or duty of the blood is to build up the substance of the body,—to form or enlarge the muscles, the skin, the cartilages, &c. I have stated elsewhere that the gluten of the vegetable food is very similar in properties and composition to the fibre of the animal muscle, and to the skin of the body. Still, chemical investigation has shown that it requires to be combined with a certain proportion of oxygen before it can actually be, or is fitted to be, built into the substance of the body. This oxygen is supplied by the lungs, and is worked up as above described.

The first good function, therefore, which the oxygen abstracted from the air discharges within the breathing animal is, that it helps to build up the solid substance of the muscles, cartilages, and skin. It forms part of the material of which they are necessarily composed; and it is in this sense that oxygen, as I have elsewhere expressed it, is a real food —that we actually live to a certain extent upon, and are fed by, the air which surrounds us.

But only part of the oxygen taken in is used thus directly, and for restorative purposes. The greater proportion of it is employed for very opposite, though equal necessary and useful ends. Thus—

Second. The body thus built up is not a permanent structure. It is constantly undergoing repair and renewal. The functions which the several parts of the body perform wear it away, as the tools we use in our daily operations are worn away by the uses to which we put them. The muscles, and liver, and brain, and bones, all waste, and the substance rubbed off, so to speak, is removed from the body, and replaced by new matter from the food.

But before it can be removed, this waste matter must again be combined with oxygen. When united with the proper proportions of oxygen, the muscle is changed into new compounds, which are soluble in water, and are carried by the fluid excretions through the kidneys and skin. Such are urea and uric acid—so called, because they are the characteristic ingredients of animal urine. These are only *oxidised* * forms of the muscle and waste tissues, which are constantly being washed out of the animal body by the fluids which escape from it.

In the tissues, also, sulphur and phosphorus exist as necessary constituents. These are not contained in the urea and uric acid above mentioned; but they combine with oxygen separately, and form sulphuric and phosphoric acids, which readily dissolve and escape with the other oxidised forms of waste matter which are rejected by the body.

Thus the second good service which the oxygen taken in by the lungs renders to the living animal, is to combine with the waste matter of its several parts. By so combining, the oxygen renders soluble, and therefore easy to be removed, what would injure the animal's health if allowed long to remain within it.

Third. A third chemical service rendered by the oxygen is no less important to the existence and comfort of the animal.

If a fat animal be stinted in its food, or be wholly deprived of nourishment for some days, its weight will rapidly diminish. It continues to breathe, and in its breath to throw off carbonic acid and watery vapour. Water escapes through the skin and the kidneys, and with it urea and the other usual constituents of the fluid excretions. The animal

* When a body combines with oxygen, it is said to become *oxidised*, and the act of so combining is called *oxidation*.

in giving off the materials of its solid substance, and, at the same time, taking little food to replace them, must necessarily lose in weight.

If we examine the condition of the animal after this period of starvation, we find that the loss of weight and substance is most remarkable in the fat of the body. This has diminished in far greater proportion than any of its other constituent portions. If, again, we inquire what has become of this fat, we find scarcely a trace of it in the solid or liquid excretions. It has been breathed away through the lungs and the skin. Breathing was necessary to the existence of life, and carbonic acid gas and watery vapour were necessarily given off with the breath. While the usual supplies of food were withheld, therefore, the ingredients of this gas and vapour were necessarily taken from the substance of the animal. It fed, so to speak, upon itself for the time. The fat which had disappeared had been used up for this purpose.

It is easy to understand how this took place.

Water consists of one of hydrogen (H) and one of oxygen (O) united to form one of water $(^{H}_{1}\,^{O}_{1})$.

Carbonic acid consists of one of carbon (C) and two of oxygen (2 O) united to form one of carbonic acid $(^{C}_{1}\,^{O}_{2})$.

Now, human fat consists of carbon, hydrogen, and oxygen, very nearly in the proportions represented by—

C.	H.	O.
87	36	5

and it is transformed into carbonic acid and water in the following manner.

The oxygen of the air is absorbed by the lungs and the skin, and is taken up by the blood in the way already described. This oxygen, as it circulates through the body, unites with the carbon and hydrogen of the fat, and, after

causing it to pass through various chemical transformations, finally changes it into carbonic acid and water. Thus—

	C.	H.	O.
1 of fat, with	37	36	5
105 of oxygen,	—	—	105
Make a sum of,	37	36	110

This is equal to—

	C.	H.	O.
37 of carbonic acid, and	37	—	74
36 of water,	—	36	36
Making the same sum of,	37	36	110

Thus, through the instrumentality of the oxygen taken in from the air, one of animal fat may be converted into thirty-seven of carbonic acid and thirty-six of water, and in this form breathed away through the lungs.

But if, instead of starving the animal, we give it abundance of fat in its food, then the fat of its own body will suffer no diminution. The oxygen taken in will transform the fat of the food into carbonic acid and water, and these will be breathed out from the lungs as before.

Or if, instead of fat, we give it food containing much starch or sugar, a similar result will follow. Instead of breathing away its own substance, the animal will throw off this starch and sugar in the forms of carbonic acid and water. It is enabled to do this as the final result of the following transformation :—

	C.	H.	O.
1 of starch or sugar,	12	12	12
With 24 of oxygen,	—	—	24
Make a sum of	12	12	36

	C.	H.	O.
But 12 of carbonic acid, . .	12	—	24
And 12 of water, . . .	—	12	12
Also make the sum of . .	12	12	86

So that, with the aid of twenty-four of oxygen, one of starch is finally changed, within the body of the animal, into twelve of carbonic acid and twelve of water, which are in whole or in part given off from the lungs.

Thus the third good purpose served by the oxygen which the vessels of the lungs absorb, is to convert the fat, starch, sugar, gum, and similar constituents of the food,—and, in the absence of these, the fat of the animal's own body,—into the carbonic acid and water which are given off from the lungs.

Among the constituents of the food above alludud to, as similar to starch in being converted into carbonic acid and water by the oxygen inhaled, are ardent spirits or alcohol. When taken into the stomach, alcohol speedily passes into the circulation, and thus rapidly supplies the materials for the production of carbonic acid to be given off by the lungs. Hence one reason for its usefulness in sustaining the strength in certain cases of slow digestion, or of great bodily weakness and exhaustion. It consists of four of carbon, six of hydrogen, and two of oxygen, and during its circulation through the body, it finally changes, like starch and sugar, into carbonic acid and water. Thus—

	C.	H.	O.
1 of alcohol, ...	4	6	2
meets with 12 of oxygen, . . .	—	—	12
Sum, . . .	4	6	14

These unite and form—

	C.	H.	O.
4 of carbonic acid, . . .	4	—	8
and 6 of water, ...	—	6	6
Sum as before, . . .	4	6	14

In the stomach of the healthy man, therefore, ardent spirits serve the same purpose as starch or sugar ; but because of their liquid form and other properties, they act more quickly. Hence both the good and the bad effects they are known to produce.

I have stated in a previous part of this chapter that the absolute quantity of carbonic acid given off from the lungs is variable, and that the kind of food we at different times make use of is one of the causes of such variation. Even when the absolute quantity of oxygen drawn in from the air is the same, the quantity of carbonic acid returned to it may differ as much as three-tenths, or nearly one-third of the whole. Thus supposing the food-substance with which the oxygen combines in the body to be at one time starch, at another fat, and at another alcohol, then a fixed quantity (say a hundred) of oxygen will produce—

From starch, . . .	50 of carbonic acid.
From fat, ...	35 of carbonic acid.
From alcohol, . . .	36 of carbonic acid.

These quantities are so related to the quantity of oxygen inhaled, that were starch and sugar alone introduced into the stomach, the *bulk* * of carbonic acid given off would exactly equal that of the oxygen taken in by the lungs. Where fat or alcohol are swallowed along with them, the bulk of the carbonic acid will diminish very nearly as the numbers above given.

The three immediate and direct chemical purposes, therefore, for which the breathing animal takes in oxygen through its lungs and skin, are to produce the substance of the solid tissues of its body from the gluten of its food—to convert the

* That this may not puzzle the unlearned reader, it is proper to state that the numbers above used do not represent *bulks* or volumes, but equivalent *weights*.

waste parts of these tissues into urea, phosphoric acid, &c. that they may be more easily removed—and to change the starch and sugar of the food into the carbonic acid and water which escape from the lungs and skin.

2°. *The indirect and physiological good.*—But these chemical operations are attended by an indirect physiological effect which is essential to the existence of life.

From what has been stated above, it does not appear that any good purpose is served by the constant production in the blood-vessels and discharge from the lungs of carbonic acid gas and watery vapour. We can see the good which the oxygen does to the animal in forming the material of its tissues, and in subsequently removing the waste matter of these tissues as they wear away; but in the simple formation of carbonic acid and water we see none.

The good in this case arises, not from the mere chemical change itself, but from a certain physical circumstance that accompanies it.

It is known that animals differ in the amount of sensible warmth which they naturally exhibit. Some, like fishes and insects, have a temperature very little higher than that of the medium in which they live. They are cold-blooded. Others, like man, and most quadrupeds, are considerably warmer than the air which surrounds them. They are warm-blooded. The internal heat of a healthy man, for example, in temperate climates, is about 98° F. In hot climates, and when he is attacked by fever, it rises to 100° F., and upwards. The horse has an internal heat of 101° F., amphibious animals of about 101½°, ruminating animals of 104° F., and birds of 106° F., while in reptiles the mean heat falls to about 80° F.

But an animal, the body of which is always warmer than the air or other medium in which it lives, must have a source of heat within itself independent of external nature.

And when we consider how much heat must be continually radiating from the surface of a warm animal into the cooler air, how much is expended in converting into vapour the water which continually escapes from its skin in the form of insensible perspiration, and from its lungs in invisible steam—how much in warming up the food and air which enter cold into its stomach and lungs, and are discharged again at a temperature nearly equal to that of the body itself—and that this escape of heat is incessant, and in a degree uniform,—all these circumstances compel us to the conclusion that this internal source of heat must be both large and constant.

Now, the main physiological difference between the warm and the cold-blooded animals is, that the former breathe, while the latter do not. It is natural, therefore, to connect together the distinctive character of breathing with the equally distinctive character of greater warmth; to suppose that the incessant breathing so necessary to life is the source of the equally incessant supply of heat from within, so necessary also to the continuance of life.

And this connection is placed beyond all doubt when we attend to the physical circumstances by which the change of starch and fat into carbonic acid and water are accompanied in the external air. If we burn either of these substances in the air or in pure oxygen gas, they disappear, and are entirely transformed into carbonic acid and water. This is what takes place also within the body.

But in the air this change is accompanied by a disengagement of heat and light—or, if it take place very slowly, of heat alone, without any visible light. Within the body it must be the same. Heat must be given off continuously as the starch, sugar, and fat of the food are changed within the body into carbonic acid and water. In this we have the continuous natural source of animal heat. Without this

supply of heat the body would soon become cold and stiff The formation of carbonic acid and water, therefore, continually goes on; and when the food ceases to supply the materials, the body of the animal itself is burned away, so to speak, that the heat may still be kept up.

The good purpose served by the production of carbonic acid and water within the body is now apparent: it keeps the body warm.

But the other functions performed by oxygen within the breathing animal are also minor sources of heat.

It is received as universally true, that whenever a body unites chemically with oxygen gas, some heat is given off, or becomes sensible. Now, we have seen—

a. That the oxygen absorbed by the blood-vessels unites in part with the gluten of the food to produce the proper chemical substance of the tissues. By this chemical change, therefore, a certain amount of heat must be imparted to the body of the animal.

b. That, again, to render the waste matter of the tissues easily removable, oxygen combines with it. The phosphorus becomes phosphoric acid, and the sulphur sulphuric acid. The nitrogen and carbon assume the forms of urea and uric acid, and so on. Every part of the substance of the body, in the course of removal, combines with more oxygen, and at every new change causes the disengagement of more heat.

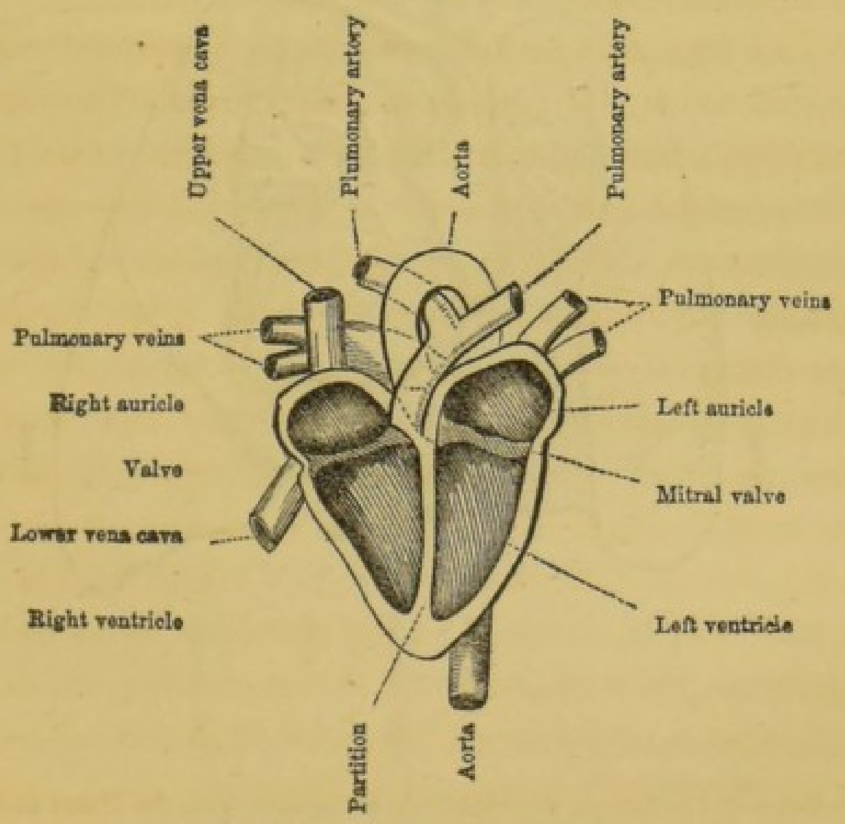
Generally speaking, indeed, we may say that all the leading chemical changes that take place within the body are processes of oxidation. Each of them sets free its quota of heat; but that particular process which yields the carbonic acid and water that escape from the lungs and skin, is the main source of warmth to the breathing animal. All the other sources, so far as we know, may for a limited time be stopped without serious inconvenience to the animal; but stop this one for a single minute, and the heart ceases to beat.

In this urgent necessity for the continuous formation of carbonic acid and water within the body of the breathing animal, we find the explanation of two remarkable circumstances, in which, were man concerned, we should say that an anxious solicitude was manifest on the part of the contriver and adjuster.

The first is the wonderful provision that is made within the animal for bringing the whole blood into frequent communication with the oxygen of the atmosphere. This is seen in the structure and connection of the lungs and the heart.

The structure of the human lungs has been already described (p. 558), and it has been stated that they contain about 600 millions of cells, varying in diameter from the two-hundredth to the seventieth of an inch. The internal surfaces of all these cells form together an area of about one

Fig. 103.

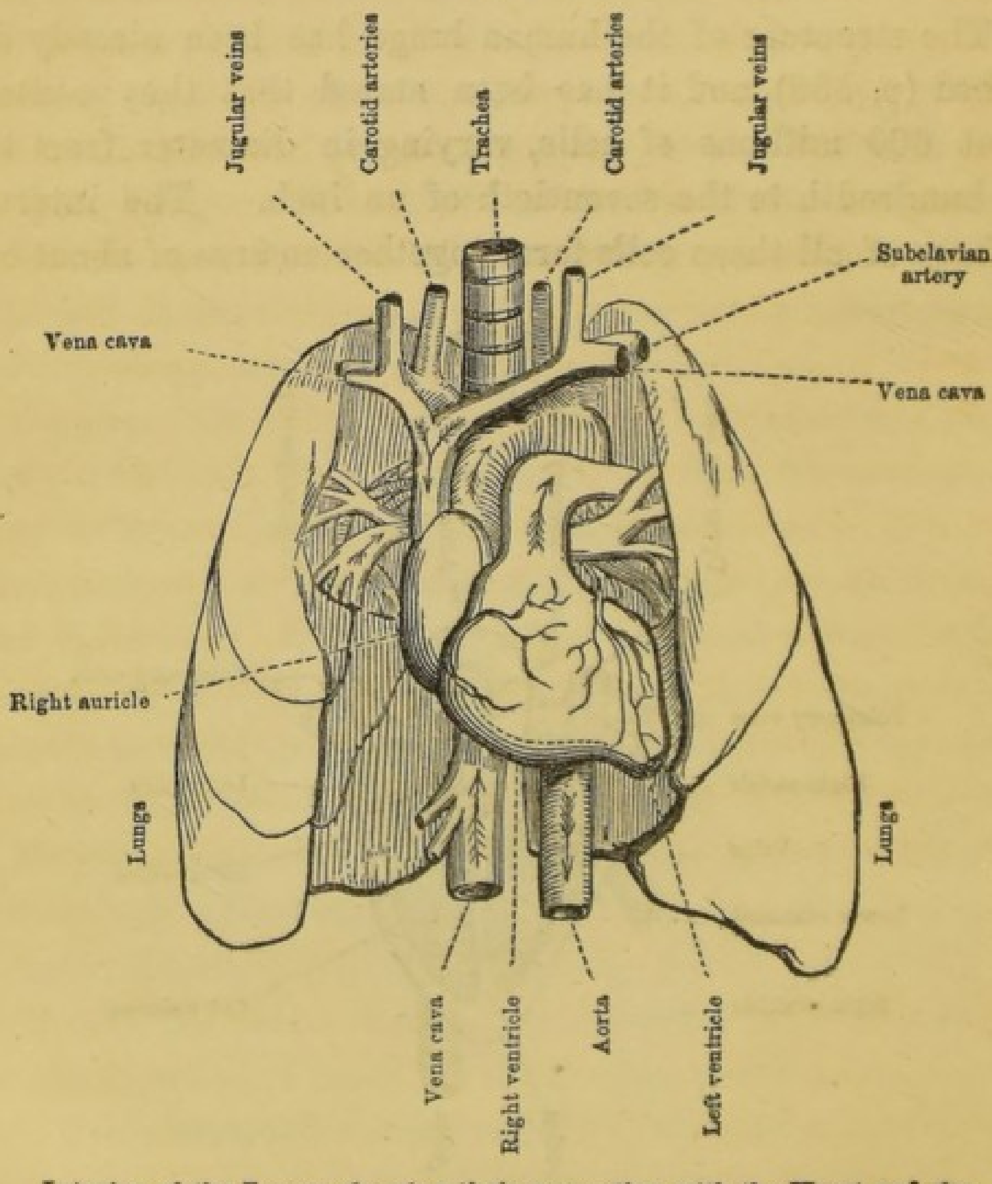


Section of the Human Heart.

hundred and sixty square yards of thin cell wall! Over the whole of this surface minute blood-vessels branch out, so as almost entirely to cover it. And along these tiny vessels the blood is continually flowing, and as it flows, drinking in through their pores the oxygen of the inspired air.

Then the heart is contrived and constructed to keep up this flow. The structure of the heart is shown in fig. 103. Returning from the extremities to the cavities here shown in the right side of the heart, the blood is thence drawn into

Fig. 104.



Interior of the Lungs, showing their connection with the Heart and the Large Blood-Vessels.

the lungs. Returning from the lungs to those on the left side, it is driven thence along the arteries, which convey it again to the most distant parts of the body.

The mutual adjustment and structural relations of the heart and lungs to each other will be better understood by a glance at figure 104.

This shows the situation of the heart between the two lobes of the lungs. The double arrow in the upper vena cava, and the single arrow in the lower vena cava, show how the blood is conveyed through these two channels into the right auricle of the heart, and the arrow ascending from the right ventricle how the blood flows from it towards the lungs. The unshaded branching vessels which connect the lungs with the unseen left auricle carry back the blood from the lungs to the heart, while the ascending arrow between the upper vena cava and the right ventricle shows the course of the aorta through which the blood from the heart proceeds on its new journey towards the extremities.*

The weight of the entire blood of a full-grown man varies from twenty to thirty pounds. Of this the lungs, in a state of health, contain about half a pound. The heart beats on an average sixty or seventy times a minute. Every beat sends forward two ounces of the fluid. It rushes on at the rate of one hundred and fifty feet a minute, and the whole blood passes through the lungs every two minutes and a half, or twenty times an hour. In periods of great exertion, the rapidity with which the blood flows is much in-

* The blood in circulating, comes from the extremities,—

1. To the venæ cavæ.
2. To the right auricle.
3. To the right ventricle.
4. To the pulmonary artery.
5. To the lungs.
6. To the pulmonary veins.
7. To the left auricle.
8. To the left ventricle.
9. To the aorta.
10. To the arteries.
11. To the capillary or hair-like vessels.
12. To the veins which lead it all back to the venæ cavæ.

Through nearly the whole of these stages its course may be traced by the aid of the woodcuts in the text.

creased, so that the whole of it sometimes circulates in less than a single minute!

How anxiously, if I may so speak, the oxidation of the blood is thus provided for—first, by the large surface over which it is made to spread within the lungs; second, by the complicated machinery of the heart, which keeps it in motion; and third, by the extraordinary rapidity, and consequent frequency with which it is compelled to flow over the wide lung-surface.

The second circumstance accounted for, is the large proportion of starch, sugar, or fat, which exists in nearly all the varieties of vegetable food on which we live. These, and especially the starch and sugar, are not required, as gluten is, directly to build up the substance of the body. They are converted into carbonic acid and water in order that the heat of the animal may be kept up. They form in every kind of vegetable food, therefore, which in any part of the world forms "the staff of human life," by far the largest portion of its weight. If it is carefully provided that oxygen shall never be wanting in the blood, equal care has been taken that the vegetable feeder shall always convey into its stomach those substances with which the oxygen can most usefully combine.

In the food of flesh-eating animals, fat serves the same purpose as starch does in that of the vegetable feeders; and in the relish for fat flesh which such animals display, we see a new provision for securing its introduction into their stomachs.

It is necessary to add to what has been said on this point, that though starch and sugar and fat are the substances which are generally converted into the carbonic acid we give off from our lungs, yet that we can live and breathe, though with less comfort, for an indefinite period without them. It is a further provision for the maintenance of

human life, that in case of emergency the gluten of the plant and the fibre of the animal flesh can be converted within the body into carbonic acid and water, and in this form be discharged in our breath. Hence the strength-supporting virtues of the dried flesh, containing probably little fat, on which the bold riders of the Pampas are for the most part sustained.

It is interesting, as giving support to the view above explained as to the source of animal heat, that in certain cases a sensible warmth is produced in plants by a similar chemical change. The leaves of plants in general give off oxygen gas in sunlight, and absorb carbonic acid gas. But to this law the leaves of flowers present an exception. They give off carbonic acid and absorb oxygen, as the lungs of animals do, and the flowers alone of all the parts of a living plant are sensibly warmer than the air which surrounds them. In most cases they are only one or one and a half degrees warmer than the air, but in rare instances they become sensibly warm to the touch. This is the case with plants of the Arum family, in one of which—the *Arum cordifolium*—the flower has been observed to have a heat of 121° F., while that of the air was only 66° F. As in the animal, it is to the union of the oxygen absorbed from the air with some starch-like ingredient in the sap of the flower leaf, that the production of this warmth is to be ascribed. This is proved by the fact that the greater the quantity of oxygen bsorbed by the flower leaf, the higher the temperature it eaches—(GARREAU.)

III. WHAT PURPOSE IN EXTERNAL NATURE IS SERVED BY THE BREATHING OF ANIMALS. Our consideration of this point need only be very brief.

The animal is not an independent part of the work or system of nature. Oxygen is not diffused through the at-

mosphere in nicely-adjusted proportions, solely that warm-blooded animals may breathe it; nor are the nicely-adjusted functions of life maintained within these animals solely for their own benefit. They breathe not less for the support of the vegetable kingdom than for their own.

We have already seen that the air which surrounds us contains about two five-thousandths of its bulk of carbonic acid gas, and that all the green leaves which flourish on the face of the earth are ceaselessly, during daylight, sucking in from the air this thinly-diffused gas. In a very few years, working as they do now, existing plants would absorb the whole, were no new supplies poured into the atmosphere to make good the rapid loss. The breathing of animals is one of the main sources from which such supplies come. The carbonic acid they pour continuously from their lungs and skin, while life lasts, takes the place of that which plants as unweariedly extract from it. And thus while the circle of natural operations within the animal is complete in itself, and in every move it makes the animal seems to work only for its own good, it is all the while unconsciously laboring for the benefit of an entirely different order of existences external to itself. On its restless activity, it is true, its own life depends, but this life itself is only part of a larger circle of operations in which material things obediently revolve in the fulfilment of a greater purpose.

Thus the breathing of man has an internal and an external end: within, it oxidises and warms the body, and renews and purifies its parts; without, it contributes to the maintenance of the general system of animated nature. To man, as a mere living animal, the former end is the most immediately interesting and important; to man, as a philosophic observer of nature, the latter is not only the grander of the two, but the most morally and intellectually beautiful.

CHAPTER XXX.

WHAT, HOW, AND WHY WE DIGEST.

What we digest.—Staple elements of food, whether animal or vegetable.—How we digest.—What takes place in the mouth.—The saliva; quantity discharged into the mouth; its composition and functions—Properties of ptyalin.—The saliva is alkaline; always on the watch for the entrance of food into the stomach.—Structure of the alimentary canal.—The stomach and its appendages.—What takes place in the stomach.—The starch, fat, and gluten, are brought into a liquid state.—Dissolving action of the pepsin.—Absorption from the stomach itself.—What takes place below the stomach.—Introduction of liquids from the gall-bladder and pancreas.—Supposed action of the bile.—Properties and uses of the pancreatic juice.—Intestinal juice or mucus.—The universal solvent.—Absorption by the lacteals.—Changes of the chyle in the lacteals—Mesenteric glands.—Absorption by the veins.—Digestion in the large intestines.—Acidity in the cœcum.—Final discharge of the food from the intestines.—Why we digest—it is to form blood.—Purposes served by the blood.—Composition of the whole man, and of his blood.—Bodily functions discharged through the aid of the blood.—Bodily waste and motion connected.—Special provisions for digestion in carnivorous and herbivorous races.—Digestion in the sheep.—Purpose of digestion the same in all animals.

What we digest, how we digest, why we digest—how wide and interesting a field is embraced by these three topics!

I. What we digest.—This topic has already been sufficiently dwelt upon in considering the bread we eat and the beef we cook. Whether we sustain ourselves by means of vegetable or of animal food, we introduce nearly the same substances into the stomach. These different forms of food consist respectively—

The *bread*—of gluten, starch or fat, and saline matter.
The *beef*—of fibrin, fat, and saline matter.

And, as we have seen, gluten and fibrin on the one hand, and starch and fat on the other, serve similar purposes, and may take the place of each other almost indifferently in a nutritious food. These, therefore, along with the saline matters contained in both animal and vegetable food, are the main substances we digest. It is true that vegetable food contains insoluble woody fibre in considerable proportion. In the bran of the bread we eat, and in the green vegetables and potatoes we consume, it is present in notable quantity; and it forms a very large part of the hay and other dried vegetable food with which cattle are fed. This woody fibre, however, passes through the animal, for the most part, useless and undigested. The digestive organs extract, from among the useless materials which the food may contain, the three staple forms of matter above described. We have only to follow these substances into the body, therefore, and see what becomes of them.

II. How we digest.—The process of digestion involves three successive series of operations, mechanical and chemical. The first of these takes place in the mouth, the second in the stomach, and the third in the intestines.

1°. *What takes place in the mouth.*—We have already seen that in ripe fruits and other kinds of vegetable food prepared by nature for immediate eating, the solid nutritious matter they contain is very minutely divided, and is intermixed with a large proportion of water. We have seen, also, that the first object of the cook, in a great number of our ordinary culinary operations, is to bring the raw food into the same minutely divided and highly diluted condition. But all the food we eat is not so prepared, either by nature or by art. The first operation we perform upon it, therefore,

is to grind it, if necessary, by means of the teeth, and to dilute and season it by means of the warm, fluid, salt-containing saliva. It is then swallowed, and allowed to descend to the stomach.

This operation appears to be altogether mechanical; and yet the chemical history of the saliva, which takes so great a part in the operation, and the relations of this saliva to the food, are both interesting and important. The saliva is secreted in glands which open into the interior of the mouth (fig. 105), and which, in some animals, are of large size. The quantity of liquid which these glands discharge into the mouth, and thence into the stomach, is very variable. In the case of the full-grown man it is sometimes as low as eight and sometimes as high as twenty-one ounces in the twenty-four hours.

The saliva consists for the most part of water, and therefore, as I have said, its first function is to dilute the food. But this water holds in solution about one per cent. of saline matter; so that, to a certain extent, it may be said also to season the food. In the twenty-one ounces sometimes swallowed in a day, there are about eighty grains of this saline matter. The seasoning this gives to the food not only renders it more grateful to the palate, but prepares it also for the after changes it is to undergo in the stomach, and the uses it is to serve in the body.

That this saline matter, though small in quantity, really does produce some beneficial effect upon the food, is rendered more probable by the influence generally ascribed to another substance which is contained in the saliva in still smaller quantity. This substance is a peculiar organic compound, to which, from its occurring only in the saliva, the name of *ptyalin* is given. Like the diastase described in a previous chapter, ptyalin possesses the property of changing the starch of the food into sugar. This property it exhibits,

according to some, when used alone—according to others only when mixed with the saline constituents of the saliva. It forms less than one five-hundredth part of the whole weight of the saliva. Not more, therefore, than from fifteen to twenty grains of it are swallowed by a healthy man in the twenty-four hours; yet this small quantity is really of much consequence to the easy and comfortable digestion of the food. Hence it is that experience has recommended to all good livers a careful mastication of their food, that all parts of it may be thoroughly mixed with the saliva, and thus subjected to its chemical action.

Two other facts regarding the saliva are of much interest as wonders of the human frame, independent altogether of their intimate relation to the process of digestion. One of these is, that the saliva has generally an alkaline* character—that this *alcalinity* is greater during and immediately after eating, and gradually lessens, till after long fasting the saliva becomes acid—that it is greater, also, after substances have been eaten which are difficult of digestion—and that, when the saliva discharged into the mouth is spat out instead of being swallowed, acidity and heartburn often ensue.—(WRIGHT). these circumstances argue not only a close connection between the process of digestion and the alkaline character of the saliva, but an immediate watchfulness, as it were, over the immediate wants of a particular bodily organ.

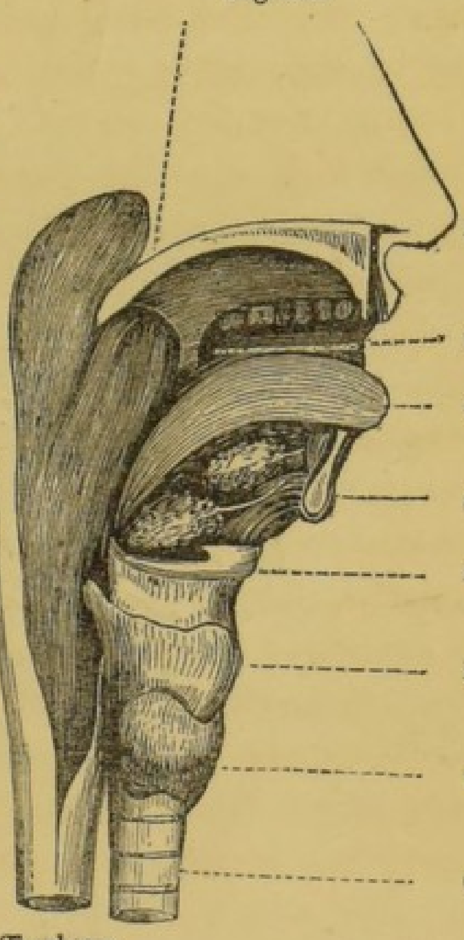
The other fact is, that as soon as food is swallowed, the saliva begins to flow more copiously than before. This is the case even if the food be swallowed without chewing. Or if food be introduced by an artifical opening into the stomach, without passing through the mouth at all, the saliva will forthwith begin to discharge itself into the mouth, with its

* Substances are *alkaline* which have the taste of pearl-ash or common soda, or which restore the colour of vegetable blues that have been reddened by an acid.

alkaline character, and hasten down the throat to assist in the digestion. It appears strictly correct to say that the saliva is constantly on the watch to be useful, when we recollect how the mouth will often "water" at the mere mention of savoury articles of diet.

When chewed and duly thinned with saliva, the food is rolled into a ball by the tongue, and is swallowed or forced down the gullet or œsophagus on its way to the stomach. The annexed fig., 105, shows the gullet cut open, and its position behind the trachea or windpipe.

Fig. 105.

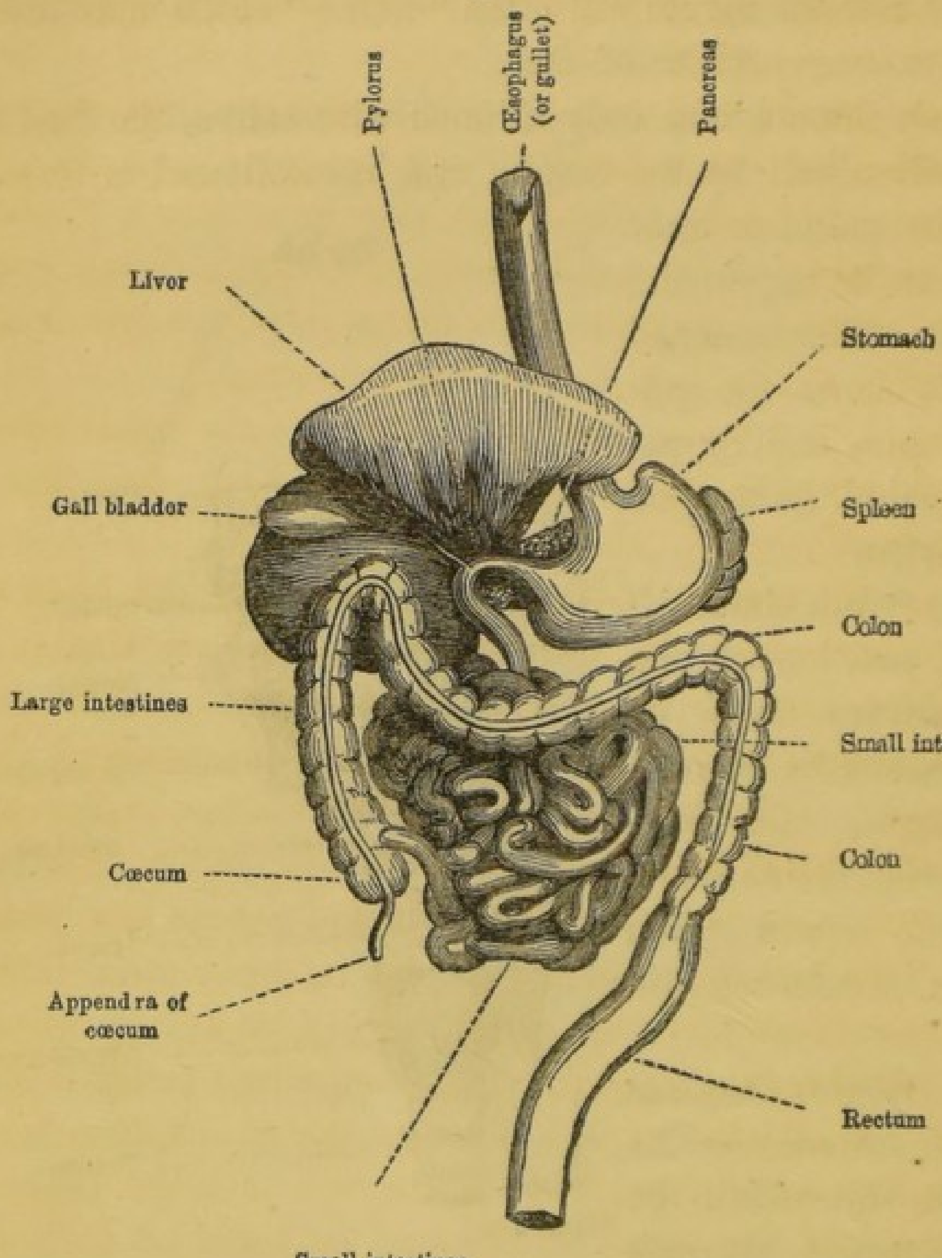


This figure shows also the position of the two salivary sacs or glands which lie beneath the tongue, and from which the saliva flows into the mouth when food is introduced into it.

2°. *What takes place in the stomach.*—The stomach, into which the food descends through the gullet, is an oblong rounded bag, capable, when moderately distended, of containing two or three pints. The annexed fig., 106, shows the form of the human stomach, and of the neighbouring organs which are concerned in the process of digestion. It exhibits, also, their relative positions and their comparative sizes. The parts, as here shown, are a little distorted, from the necessity of turning up the liver

in order that the gall-bladder, the pancreas, and the upper part of the intestines might be more distinctly seen.

Fig. 106.



The food after it reaches the stomach is mixed up with more water if it has not been already sufficiently diluted. It is intermingled, at the same time, with certain liquids which flow out of minute openings on the inner surface—the mucous membrane, as it is called—of the stomach. And after these admixtures, it is digested for an indefinite period, at a constant temperature of about 98° F.

But during this digestion it undergoes certain chemical changes. Thus—

First, The *starch*, through the continued agency of the saliva, and especially of the ptyalin it contains, is gradually converted for the most part into sugar. It then dissolves, and is ready to be conveyed towards its further destination.*

Second, The *fat*, without undergoing any known chemical change, is subdivided into exceedingly minute globules, and is intermingled intimately with the other half-fluid portions of the food. With these it forms in this way a kind of emulsion, and is then also ready to pass on.

Third, The *gluten and fibrin*, which are solid when swallowed are also reduced in the stomach to the fluid form. But this is effected by means of a new agency.

Within the mucous membrane which lines the interior of the stomach, many little cavities or hollows are situated. From these, through little mouths or openings into the stomach, a liquid flows which is known by the name of the gastric juice. This liquid contains saline matter, a quantity of free acid, which renders it slightly sour, and a peculiar organic substance to which the name of *pepsin* has been given. This last substance is present in the gastric juice only in minute proportion. Like the ptyalin of the saliva, however, it exercises a powerful and important action upon the food. While the ptyalin changes the starch, first into sugar, and afterwards partially into lactic acid, the pepsin, with the aid of the free acid, reduces the fibrin of flesh to the liquid state. The curd of milk and the white of egg are also readily changed by the gastric juice into soluble forms. Upon gelatinous substances it exercises a specially

* The saliva of some animals appears to be much more powerfully solvent than that of man: thus the saliva with which the *boa constrictor* covers the body of its victim is said to promote a very rapid decomposition. The muscular flesh is rendered gelatinously soft under its action, so that the animal is able to force entire limbs of its slain victim through its swelling throat.—(See HUMBOLDT, *Views of Nature*.

dissolving action; and upon the gluten of wheat, though a little more slow, its final effect is the same. Of this gastric juice as much as 60 or 80 ounces are supposed to be poured into the stomach of a well-fed grown man every twenty-four hours.

Thus, by the conjoined chemical agency of the saliva and the gastric juice—aided by the uniform warmth of the stomach—the fat, the starch, and the gluten of the food, are all brought into a half-fluid state. The saline matter of the food is in part changed and dissolved by the same agencies. The whole forms a greyish, gruel-like, slightly acid food-pulp, which has been called chyme.

This chyme now flows through the narrow outlet from the stomach—the pylorus (see fig. 106)—into the upper part of the small intestines, which, from its length of twelve inches, has been called the duodenum.

All the food, however, which enters the stomach does not thus linger in the stomach itself, or thus pass downwards through the pylorus.

What we swallow in the liquid state—our gruels and gravy-soups, for example—requires no dissolution or breaking down in the stomach. They pass on, therefore, with little delay, and for the most part descend through the pylorus into the duodenum in a comparatively short period of time.

And again, from the moment that our solid food begins to dissolve in the stomach, it begins also to be absorbed through the sides of the stomach itself. Minute blood-vessels spread over the whole internal surface of the stomach, drink in liquid parts of the food through their thin walls, and carry them away to be mingled with the general blood. Thus, a variable proportion of the food never reaches the pylorus, nor descends into the duodenum. Thus, also, the process of nourishment begins almost as soon as the food is introduced into the stomach. The strength is kept up by

one part of it, while the rest is undergoing the necessary processes of chemical preparation.

3°. *What takes place after it leaves the stomach.*—A glance at the woodcut (fig. 106) shows a small vessel or tube proceeding from the gall-bladder, and entering the duodenum a little below the pylorus, or outlet of the stomach. Another vessel, not seen in the figure, comes in from the pancreas or sweetbread. The former pours bile into the intestine; the latter, a thin saliva-like liquid, called the pancreatic juice. At the same time, from the surface of the intestine itself, a peculiar half-liquid slimy mucus exudes, which is called the intestinal juice (*succus entericus*). With these three liquids the food-pulp or chyme almost immediately mixes as it passes onward from the stomach. When so mixed it loses its acid character, and becomes milky in appearance. It is now changed into chyle.

The first chemical effect of the bile is to remove the acidity of the food-pulp. Its subsequent action is not well understood, but its presence is known to be necessary to healthy and nutritious digestion. It restrains the tendency of the food to fermentation, and to that form of decay, or decomposition, which is indicated by flatulence and the occurrence of diarrhœa. It also provokes the surface of the intestines to discharge more copiously the intestinal juice, and it tends to keep the bowels in movement. But the chemistry of all this is not yet explained.

The pancreatic juice resembles the saliva very much in appearance. Like the saliva, also, it contains saline matter, and a peculiar organic compouna, which however is different from the ptyalin of saliva. In common with ptyalin, this compound body possesses the property of converting starch into sugar, and thus continues in the bowels the transformation of the starch which the ptyalin had begun in the stomach. It exercises a peculiar action, however, upon the

fat of the food, reducing it to a more minute state of division than before, converting it into a more perfect emulsion, and giving to the chyle its characteristic milky appearance. Its special duty is believed to be to promote the digestion of oily and fatty food.

The intestinal juice aids the action of the fluid of the pancreas. It has the property of changing starch into sugar, and at least assists in emulsifying the fat.

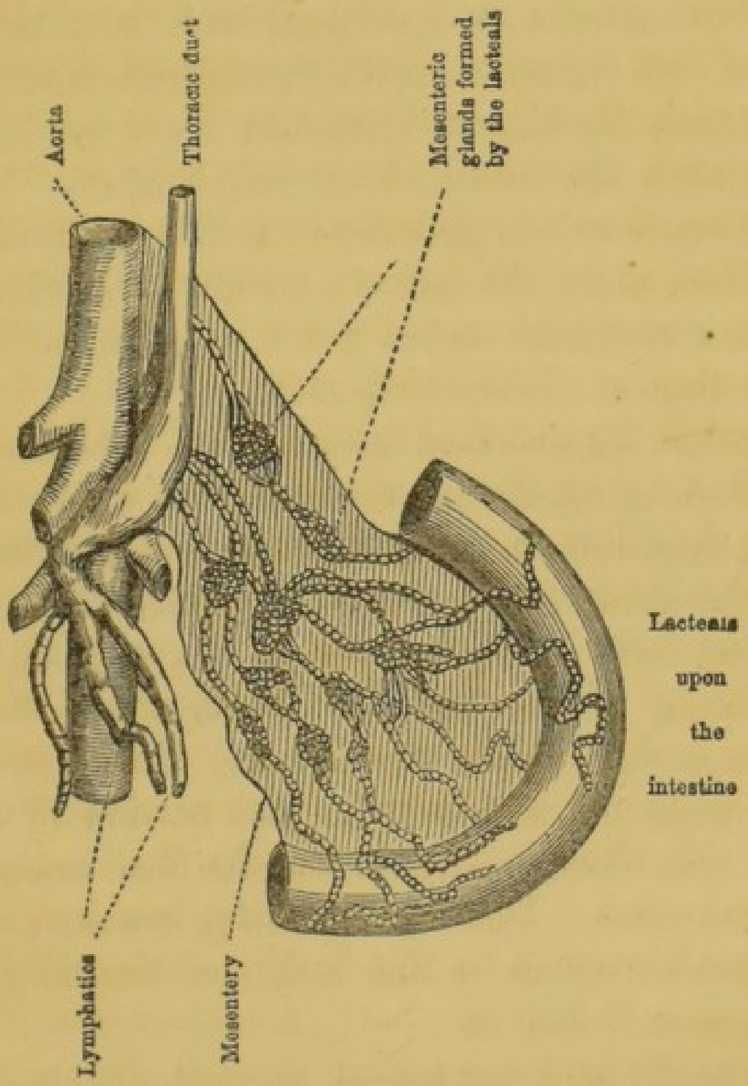
This latter action is inferred from the fact, that the solution of the whole food is much more complete and rapid when it is mixed with all these fluids together, than when treated with one of them only. They promote the chemical action of each other, so that the mixture of the saliva, the gastric juice, the intestinal juice, the bile, and the pancreatic fluid, forms a kind of "universal solvent," by which all that the food contains of a nutritious quality is melted together, as it were, and fitted to enter the absorbent vessels.

And now the chyle being formed, a new variety of absorption begins. While within the stomach, the fatty and glutinous portions of the food were still too little reduced to admit of their being taken up in suitable quantity by the absorbent vessels. The liquid matters which entered into them, therefore, had more of the watery, half-transparent appearance, which is indicated by the word *lymph*. But the moment the food-pulp passes the outlet of the bile, it becomes milky, and the absorbing apparatus drinks in this milky liquid, and fills with it the vessels called *lacteals*, or milk-bearers. Throughout the whole of the smaller intestines, the same operation goes on. The intestinal juice is continually poured out and mixed with the food as it descends. It is more and more digested and exhausted of its nutritious matter, and lacteals continue to convey from it, at every point in its descent, fresh supplies of the milky chyle.

On its way through the lacteals, the chyle undergoes

further chemical changes. To promote these changes it is detained here and there by being obliged to pass through several knots or glands, where many of the lacteals meet together and intermingle their contents. Finally, all the lacteals terminate in the thoracic duct—a vessel which in man is about as large as a goose-quill—and by this duct the chyle is conveyed into the jugular vein (fig. 106). Thence it is forced forward to the lungs, where it assumes a red colour, and contributes continually to the formation of new blood.

Fig. 107.



The following fig., 107, shows how the lacteals are distributed upon the intestines,—how they subsequently collect

together in glands or knots, as they pass along the mesentery or membrane to which the intestines are attached,—and how they finally terminate in the thoracic duct.

But besides this absorption of the milky fluid, called chyle, which is conveyed to the blood-vessels by the lacteals above described, another absorption goes on continuously from the internal surface of the intestinal canal. Over the whole of this surface, as is the case with the interior of the stomach, a fine network of minute veins is spread, like the delicate network which lines the air-cells of the lungs. Through the thin sides of these vessels liquid substances pass with greater or less ease; and from the fluid contents of the digestive canal, throughout nearly its whole extent, such liquids do enter into these minute veins, and mingle with the blood which they contain. In this way nourishing materials, probably of a different kind from those which flow along the lacteals, mingle with the rest of the blood, are conveyed to the heart, and are finally employed for the support of the living body.

What is the chemical nature of the substances which are thus taken up by the minute absorbent veins, or what proportion they bear to the quantity of nutritive matter carried off by the lacteals — in regard to both these points we are yet in the dark. All that enters the veins in this way is immediately mixed with the blood, which the veins are bringing back from the extremities. Hence it is very difficult to make out satisfactorily what portion of the constituents of this blood is drawn from the food contained in the intestinal canal. That the quantity, however, is large, and its nature important to the health of the animal, there is every reason to believe.

When the food has passed through the small intestines and reached the cœcum (see fig. 106), the nutritious matter it contains is nearly exhausted in consequence of the differ-

ent forms of absorption above described. A change here takes place, however, in its chemical character. When the food pulp escaped from the stomach, it was slightly acid. The admixture of the bile made it alkaline, and it has continued so throughout the whole of the smaller intestines. But in the cœcum it becomes slightly acid again, chiefly from the presence of free lactic acid. How this change is brought about is not clearly understood. The purpose, however, seems to be, by the agency of this acid to dissolve out any remaining gluten which the contents of the bowels, and especially their vegetable contents, may retain, and thus more completely to exhaust them of nutritive matter. This is rendered more probable by the large size of the cœcum in herbivorus animals. The residual food is detained there for some time, that it may undergo a final digestion before it is altogether discharged from the bowels.

Such is a sketch of the process of digestion—of the way in which it takes place—of the complicated apparatus and organs which take part in it—and of the chemical agents which are specially prepared and always ready to assist in it. One long preliminary cooking process goes on from the mouth downwards all the way to the colon, and from every part of this long canal tiny lacteals and absorbing veinlets carry off contributions of cooked food either to the general store of chyle, which is collected in the thoracic duct, or to the venous blood which is hurrying back to the heart. How effectual all this digestion is in exhausting what we eat of its nutritive matter, may be judged of from the fact, that a healthy grown man, fed with ordinary diet, rejects of undigested and of waste or used-up matter, both taken together, only from four to six ounces daily. And this rejected matter consists of—

Water,	3	to	4½ oz.
Organic matter,	0¾	to	1⅛
Mineral matter, chiefly phosphates of lime and magnesia,	0¼	to	0⅜
	—		—
Total,	4	to	6 oz.

Or he discharges one to one-and-a-half ounces of dry solid matter daily!

III. Why we digest.—This question is, in a certain restricted sense, already answered by the preceding statements. We digest our food that we may prepare materials for the production of blood.

Of what substances, then, does this blood itself consist?

If a hundred pounds of human blood be rendered perfectly dry, by a heat not much exceeding that of boiling water, it will be reduced in weight to somewhat less than twenty-two pounds. It loses about 78½ per cent of water.

This dry matter consists essentially of the same substances as the several varieties of animal and vegetable food described in the previous chapters. It contains fat, a little sugar, a little starch, fibrin, albumen, gelatine, and saline matter in the following average proportions:—

Fibrin, albumen, gelatin, &c.,	93 per cent.
Fat, a little sugar, and a trace of starch,	2
Saline or mineral macter,	5
	—100

In composition, therefore, it very closely resembles the muscular parts of lean animals and fish which we eat as food. The gluten of our vegetable food is represented in the animal by the albumen and fibrin.

The composition of the blood varies slightly with the age, sex, constitution, state of health, &c. of the individual. On the whole, however, it is very nearly represented by the average composition above given. For the immediate formation of blood, therefore, animal food is better adapted than the more usual varieties of vegetable food.

We digest our food that this blood may be formed from it.—This answer does not go far enough in explaining the purpose served by digestion. The blood being formed as the result of the processes above described, what purpose does it serve? An explanation of this purpose will give the true answer to the question, Why we digest?

The blood serves a double purpose. *First*, it supplies the materials which are necessary to build up and to promote the growth of the several parts of the body. *Second*, it enables the body, without loss of substance, to discharge the functions on which its life depends.

First,—It builds up and increases the body. To understand this part of its office, it is only necessary to consider of what substances the body and blood respectively consist.

We have already seen that both animals and plants consist for the most part of water. The model man of Professor Quetelet weighs 154 lb., and he consists of—

Water,	116 lb.
Dry matter,	38*
	154 lb.

And this dry matter consists of—

Flesh and fat,	24 lb.	or of	Organic matter (combustible),	28 lb.
Bone,	14		Mineral matter (incombustible),	10
	38			38

The proportion which the fat bears to the dried flesh varies in different individuals, and in the case of man has seldom been experimentally determined. In sheep only moderately fat, it forms one-third of the whole. If we take it at one-fourth in our model man, then his 154 lb. will consist of—

* How small a quantity of solid matter is consistent with life in a grown man, may be judged of from the case which lately occurred in this country of a stepmother ill-using and starving a boy of ten years of age till he weighed only twenty-five pounds! He was in appearance merely skin and bone. Supposing him to be only two-thirds water instead of three-fourths, the solid matter in his living body would be only about eight pounds!

Water, ...	116 lb.
Flesh, skin, and blood, containing ·777 lb. of mineral matter,	18
Fat, ...	6
Bone, consisting of { Gelatine, 4¾; Mineral matter, 9¼ } . . .	14
	——154 lb.

But the blood which is to sustain the substance of the body is itself included in the above general composition of the whole man. This blood weighs, in the liquid state nearly twenty pounds in a healthy full-grown average man, * and it consists very nearly of—

Water, ...	15⅔ lb.
Dry solid matter, ...	4⅓
	——20 lb.

And this dry solid matter contains—

Fibrin, albumen, &c., ...	4 lb.
Fat and a little sugar, ...	0·222
Mineral matter, about	0·111
	4·333 lb.

Deducting this from the dried body as a whole, we have—

In the body which is to be sustained.	lb.	In the blood which sustains it.	lb.
Flesh, skin, and gelatine, without mineral matter,	17·888	Fibrin, albumen, &c., .	4
Fat and a little starch, . .	5·777	Fat and a little sugar, .	0·222
Mineral matter, . . .	10	Mineral matter, . .	0·111
	33·666		4·333

The flesh, skin, &c., of the body are formed and sustained by means of the fibrin and albumen of the blood. The fat and mineral matter of the latter also directly supply the want of these substances in the body. The arteries convey these different forms of nutritious food to all parts of the body. There they are taken up by the minuter vessels to which this labour is intrusted, and by them they are conveyed to the precise points where they happen severally to be required.

It will strike the reader who compares the absolute

* See CARPENTER'S *Human Physiology*. Fourth Edition, p. 134.

quantity of dry matter contained in the blood with that which forms the body, how very small a store of food the animal carries within itself. The blood contains by weight only one-eighth of the dry matter of the body, so that the strength of the latter could be sustained only for a very short period without supplies from other sources.

And yet, though the strength must fail, it is remarkable how long life will cling to the wasting body. An animal does not die of starvation till it has lost two-fifths of its weight, and more than a third of its heat. The lamp of life continues slowly and faintly to burn. It expires at last, partly from the failure of fuel, and partly from stoppage of the circulation by the increasing coldness of the extremities. But—

Second,—The blood enables the body, without loss of substance, to discharge those functions on which its life depends. And it is in considering how much is implied in this duty of the blood, that the necessity of constant and large supplies of food from without becomes most apparent.

While man lives he breathes and moves. What demand for nutritive matter does the exhibition of these characteristic appearances of life involve?

In the preceding chapter we have seen that the animal eats a large portion of food in order that it may combine with the oxygen taken in by the lungs, and then be breathed away again in the form of carbonic acid and water. But before it can so combine with oxygen, it must be digested and conveyed into the blood. Thus it may be said with truth, that *we digest in order that we may breathe.*

And as this breathing is continually going on, the blood must as constantly supply the materials out of which the carbonic acid and water may be produced. But that it may do so without lessening its own substance, new streams of chyle must be ever flowing into it, and new food digested, that this chyle may be formed. Hence the necessity and

use of that large quantity of starch or fat which a full-grown man must daily eat if he is to continue to breathe, and yet retain the weight of his body undiminished.

Again, the living man moves. Look at him externally, and he is never wholly at rest. Internally, could we look at him, he is everywhere and always in motion. Even when sunk in sleep, there is scarcely an organ of his body which, if not moving itself, is not the seat of incessant motion. Now it is believed that every movement of the body—every stirring of the limb—every change, for example, in the position of my fingers as I write—every involuntary beating of my heart— every thought that passes through my brain —is accompanied by a change of matter greater or less in quantity at the particular spot where the movement takes place. A portion of the substance of the muscle, of the bone, of the heart, of the brain, becomes chemically changed —oxidised probably— unfit, therefore, for the position it previously occupied as a part of the perfect body. All this altered or waste matter is continually undergoing removal through the veins, and its place is as continually supplied by new matter extracted from the arterial blood.

That all bodily movement is attended by waste of the bodily substance is a received opinion. But whether such movement is or is not its true cause, the waste itself is certain. An animal, when fasting, will lose from a fourteenth to a twelfth of its whole weight in twenty-four hours. This loss does not fall altogether upon the fat, but extends also in part to the tissues and general substance of the body. It is so great that the whole blood is unable altogether to replace it. Scarcely, therefore, is the stomach of an animal empty, when it begins already to feed upon itself.

But even when an animal is fully fed, so that it can discharge the requisite quantity of carbonic acid from its lungs without in any way feeding upon itself, still, as I have said,

a waste and renewal of the tissues and substance of the body everywhere goes on. It matters not whether this waste is a consequence of the perpetual movement of its parts, or arises from some other cause. It is known to proceed so rapidly that the whole body is now believed to be renewed in an average period of not more than thirty days! Of course the rapidity of the general change of substance varies with the individual, his habits, his food, and his employment. The several parts of the body, also, will probably waste with different degrees of rapidity. If the amount of movement or labour performed by each part, for example, be the measure of the degree of waste—then, where much thinking is done, the brain will be more speedily renewed—where much bodily toil is undergone, the muscles called into action by the kind of toil will be oftenest changed and rebuilt—and where listless indolence and inactivity possess both body and mind, muscles and nerves alike will partake of a correspondingly slow change of substance.

Thus it may be said again, and with equal truth, that *man digests in order that he may move;* or he digests that he may repair the constant waste which is ascribed to the restlessness of the material particles which compose his ever-moving body. This waste the blood makes up; and the process of internal cooking must be continually going on in order that the blood may be able to discharge this duty without causing any permanent loss of substance to the body itself.

The questions we proposed to ourselves at the commencement of the present chapter are now answered.

What we digest consists essentially of the starch, fat, gluten, and mineral matter, which, as we have seen in a previous chapter, all varieties of nutritious food contain in greater or less proportion.

As to how we digest, it is through the united agency of the

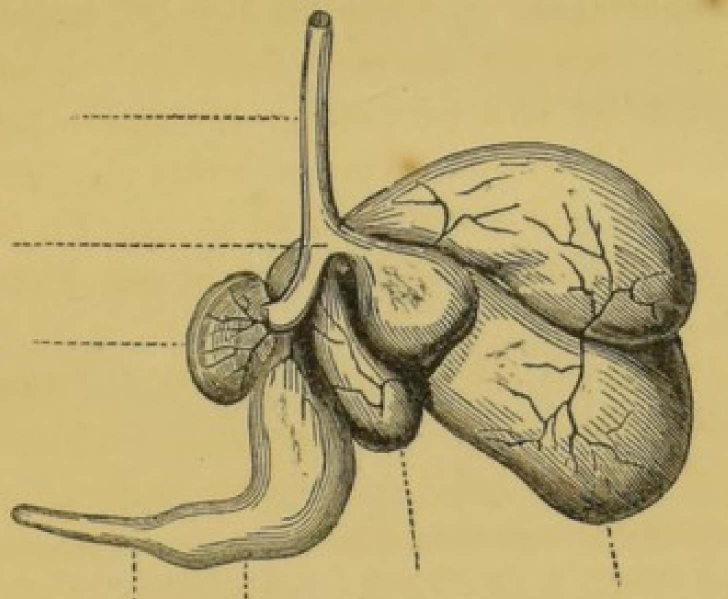
warmth of the body—of a curiously constructed alimentary canal and its appended organs—and of various chemical substances poured into the food from the sides of this canal, and from its subsidiary organs.

And the purpose for which we digest is, more immediately, to pour into the thoracic duct and absorbent veins the materials for the production of blood: but, more remotely, to build up the full-grown living man, and to enable him to breathe, move, and perform all the functions necessary to life, without sensible or permanent loss of his own substance.

These three most interesting questions I have answered with special reference to the constitutional history of man. Were they asked in reference to other races of animals, the answers to the first two would be somewhat different. In fact, the nature of the food—of the thing to be digested—determines the form of the apparatus in which the digestion takes place, and also, in some degree, the chemical substances by which it is promoted. Thus in the carnivorous races,—living upon flesh, which is more easily converted into chyle—the stomach is small, and the alimentary canal comparatively short. But in herbivorous animals the canal is long, and the stomach large, and sometimes complicated in structure. In such as ruminate or chew the cud, this is particularly the case, as may be seen in the following figure, which represents the fourfold stomach of the sheep. In the case of this animal, the food which is cropped or swallowed hastily passes unchewed into the large first stomach or paunch. Here it is moistened with a fluid admixture, and when required, is passed on to the second stomach, and thence back to the mouth to be masticated. When chewed it is swallowed again, and proceeds at once to the third stomach or many-plies, and thence forward to the fourth stomach or reed, where the true gastric juice is mixed with it. From

this latter it passes, as in man, through the pylorus into the intestines, which are greatly longer than in man.

Fig. 108.



The reason of all this complication in the digestive apparatus of the ruminating animal, is the difficulty of grinding down, and then of extracting, the whole of the nutritive matter from the kind of vegetable food on which the animal lives. Hence the food is longer detained in the alimentary canal, and is subjected to a more thorough process of subdivision and exhaustion, before it is allowed to escape from the body.

The chemistry of comparative digestion is indeed ric in interest and instruction; and, did my space permit it were easy to multiply illustrations of the way in which the instruments and means of digestion are adapted in every animal to the circumstances in which it is placed, and to the habits of life in which it is intended to indulge.

In all animals, however, the end or purpose of digestion is the same,—to provide materials for building up its body to a full size, and afterwards for enabling it to discharge its various living functions, without permanent loss of its own weight or substance.

CHAPTER XXXI.

THE BODY WE CHERISH.

The body and its habits an assemblage of chemical wonders.—Change of the food in its passage from the mouth to the lacteals.—Globules or corpuscles of the chyle.—The blood corpuscles; their form and composition.—Mineral matter within and without the corpuscles.—The corpuscle is an independent microcosm.—Selecting power of the parts of the body.—How the whole system is kept in working order.—Activity of the vessels which remove waste matter.—Change of the capacity of the blood for heat in passing through the lungs.—How this affects the warmth of the body.—Other provisions for comfortable warmth.—Craving for special kinds of food.—How this is artificially met.—The nature of the water we drink may modify natural cravings and natural diet.—The potato and water of Ireland.—Instinctive choice of beverages and condiments.—Case of salt; how instinct regulates the use of this substance.—Examples in South-western Africa and in Siberia.—Susceptibility of the body to the action of very minute portions of matter.—The narcotics, the beverages, the odours, and the miasms.—Influence of light upon the body.—The structure, functions, and special composition of the grey and white parts of the brain.—The rete mucosum.—The chemistry of all parts of the body deserving of intelligent and reverential study.

Nearly all the functions and habits, natural and acquired, the chemical history of which has formed the subject of the preceding chapters, have a relation more or less direct with the welfare and comfort of the body. Besides ministering to its necessary wants, we nourish and fondly cherish it. And in attempting to pleasure and pamper, we often injure it. This arises from our possessing, for the most part, too imperfect a knowledge of its vital wants and functions. We

are too little familiar, also, with the substances we daily use or occasionally indulge in, or with which, in external nature, we cannot avoid coming into contact. And with this ignorance of the things themselves, is necessarily associated a similar ignorance of the effects they are likely to produce upon the system.

This want of knowledge is by no means surprising, seeing that the whole grown-up man—the body and its habits together—may be described as an assemblage of chemical wonders. Besides the main features in his chemical history which have been already illustrated, there are a thousand others of a less general kind, the study of which is not only rich in the discovery of wise contrivances, so to speak, but is pregnant also with practical instruction. To some of these minor points I propose to devote the present chapter.

We have already seen how many curious circumstances attend the food in its progress from the mouth to the blood-vessels. The teeth grind it fine, and the tongue mixes it with the saliva. The saliva, on the watch to be useful, rushes out and makes the mouth water whenever savoury food is spoken or even thought of. It flows most copiously, however, while we chew and while we are digesting. In doing so, the saliva not only moistens and seasons the food, but mixes up with it the substance ptyalin, which converts its starch into sugar, and is essential to the healthy progress of digestion Then from the coats of the stomach exudes the gastric juice—also most copiously when there is most work to do. This fluid brings with it the peculiar substance *pepsin*, which renders soluble the gluten and flesh of the food. When this solution is accomplished, the gastric juice ceases to flow, and the liquid food moves forward to the smaller intestines. Here the sour chyme is mixed with three fluids which are waiting its approach. A valve opens, and the bile comes out to meet the food—a juice flows forward

from the pancreas, like a new saliva—and from the surface of the intestines, as it passes along, a third liquid issues to temper and chemically change it. The chyle, now milky and alkaline, is taken up by the lacteals. These minute vessels are distributed along the whole course of the intestines, extracting, at every step in its progress, new portions or constituents from the food, mixing them altogether as the vessels meet in the glandular knots, and pouring the mixture into the one common reservoir—the thoracic duct. And to insure a thorough extraction of all feeding matter, a new change takes place when the food descends into the larger intestines. It becomes acid again, and delivers to the still busy lacteals new materials with which to give the final tempering to the milky chyle as it flows towards the true blood-vessels.

All this has been explained. But it will amply repay us if we follow a little further the chemistry of this incipient blood.

Fig. 109.

Fig. 110.

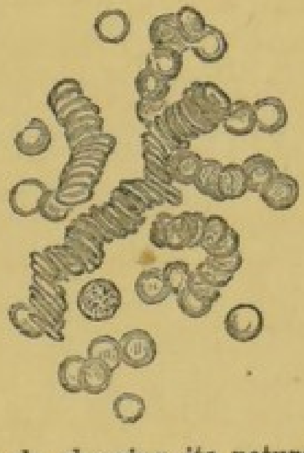
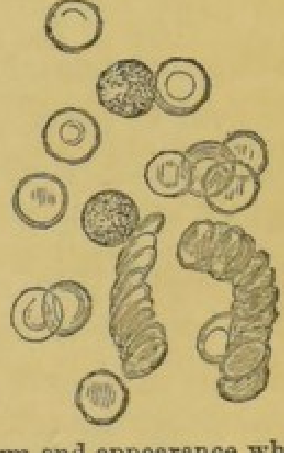


Fig. 111.



109. "The human red corpuscle, showing its natural form and appearance when brought fully into focus, in which case the centre always appears light. Scattered over the field are seen one or two white corpuscles (*b*)."

110. "The same seen united into rolls, as of miniature money in appearance.

111. "The blood corpuscles of the elephant, red and white, which are the largest hitherto discovered among the Mammalia." All magnified 670 times.—(From HASSALL's *Microscopic Anatomy*).

Seen under the microscope, the milky contents of the

thoracic duct have very much the appearance of blood Numberless rounded discs present themselves, which, by their peculiar granulated appearance, are recognised as the colourless corpuscles which characterise the blood (fig. 109*b*). As soon as these enter the veins, however, and are thence driven over the lungs, they become coloured. By some unknown chemical action of the oxygen which they absorb in the lungs, they are made to assume a red colour, and are no longer distinguishable from the true red corpuscles of the blood.

Digestion may now be said to be completed, and true blood is formed. This blood is itself a most interesting study. Under the microscope the blood of man and other mammiferous animals is seen to consist of minute flattened disc-like bodies (corpuscles) of a red colour, floating in a colourless liquid. These bodies vary in size and shape in different animals. Those of man have an average diameter of 1-3200th of an inch, and a thickness of 1-12,400th, being larger than those of any of our domestic animals, (figs. 109 and 110). Those of the elephant are the largest yet known among mammals, (fig 111). In oviparous vertebrates they are oval in form, and in the frog much larger than in man. When dried, they form, in man, on an average, about 13 per cent of the whole weight of the newly-drawn blood. In a moist state they form a little more then half its weight. They consist of an outer husk or skin enclosing a coloured fluid, in the centre of which a minute kernel, or nucleus, is seen, while they are still young. When fully formed, this nucleus disappears. The fluid of the corpuscles contains the colouring matter of the blood (*hematin*), particles of fat, a colourless substance (*globulin*), which belongs to the same class of chemical compounds as gluten, albumen, and fibrin, and a portion of saline matter. Among the most interesting

facts connected with the corpuscles is the relation which this saline matter bears in kind to that of the whole blood.

We have already seen that the blood contains a considerable proportion of saline or mineral matter; so that, when dry blood is burned, it leaves about 5 per cent of ash. More than half of this ash (57 per cent) is common salt; the rest consists of potash, soda, lime, magnesia, oxide of iron, phosphoric acid, and sulphuric acid. Of these substances the potash, the phosphoric acid, and the iron, are principally contained in the corpuscles; while the common salt especially abounds in the colourless liquid or serum in which the corpuscles are seen to float.

Countless absorbent vessels are continually bringing new liquids, and pouring them into the blood, and almost as many are continually removing from the blood certain portions of its contents, and yet this relative position of its saline constituents is continually maintained. The thin husk which envelopes the corpuscles allows some of these substances to pass abundantly into the interior, while others of them it in a great measure excludes. This separation is probably effected with a view to the after-formation of flesh, since the animal flesh agrees with the corpuscles of its blood in containing much potash and phosphoric acid, with comparatively little common salt.

It is very interesting to observe how, in so important a fluid as the blood, the several substances it contains thus eparate themselves into distinct groups with a view to after uses. Each corpuscle is, in fact, a minute microcosm, within which changes chemical, and perhaps vital, take place, independent, in a sense, of all around it. At the same time, a jealous discriminating power, as it were, guards it around, by which this substance is admitted, and that one refused a passage through the pores of its encircling membrane.*

* This lends much countenance to the opinion of John Hunter, still entertained by physiologists, that parts of the blood really live.

But, indeed, a discrimination of this kind appears to reside in all parts of the body. All are endowed with the power of selecting from the universally nourishing blood the chemical compounds which are specially required for the formation of their own substance, or the discharge of their special functions. Thus the bones specially select and appropriate phosphate of lime, while the muscles take phosphate of magnesia and phosphate of potash. The cartilages build in soda, in preference to potash. The bones and teeth specially extract fluorine. Silica is almost monopolised by the hair, skin, and nails of man, and by the horns, hair, and feathers of animals. Iron abounds chiefly in the colouring matter of the blood (*hematin*), in the black pigment of the eye, and in the hair. Sulphur exists largely in the hair, and phosphorus in the brain. Thus, to each part of the body certain chemical substances seem to be most specially appropriated, and to each part a peculiar and special power has been given of selecting out of the common storehouse those materials which suit it best to work withal.

And what is still more admirable, the formation and renewal of each part of the body serves the definite purpose of preparing the blood for the production or renewal of the next part it visits as it flows along. Thus the blood is continually changing as it proceeds in its course, leaving and taking up something at every new spot, and by these changes being always rendered more fit for the next duty it has to perform—(PAGET).

Nor is it less interesting to observe how every function of the body is on the alert, as it were, to keep the whole system in working order.

That the blood may subserve its various uses, its natural composition, though continually changing, as I have said, must not be materially altered. It may vary in composition

within certain small limits; but when changed beyond these limits, the functions of the whole body begin to be deranged. Hence such a change is carefully provided against.

If, for example, much water is poured into the stomach, the chyle is diluted, and the lacteals convey a thin fluid to the blood-vessels, and the blood itself becomes more watery than usual. But instantly to remedy this, the lungs, the skin, and the kidneys of the healthy man become more active, the excess of water is carried off, and the blood is thickened again to its usual condition. And so some kinds of food tend to increase the quantity of fat in the blood; others that of albumen; others that of common salt, &c., beyond the average proportion; but the ever ready removers begin their more active work before any such excess becomes sensible in the healthy man, and continue it till the natural condition is restored.

But the unsleeping activity of the vessels which remove from the blood what it ought nowhere to contain in very sensible proportion, is most remarkably shown by the rapidity with which they carry off those refuse substances which are derived from the natural waste of the tissues. The lacteals are continually conveying new materials to the blood, to rebuild the wasting portions of the body. Of course the changed substance of the wasted tissues is poured into the blood quite as fast. But so diligent are the vessels and organs whose duty it is to remove this now useless matter, that mere traces of it only can ever be detected in the blood of a healthy man. The kidneys, especially, are on the alert to pick it up, to hurry it away from the blood as rapidly as it appears, and to discharge it by way of the urine. The kidneys are thus the chief cleansers of the vital fluid. In immediate importance to life they stand next to the lungs. We may cease for days to carry food into the body without serious injury to life; but let the removers intermit their

operations for a single day, and the blood would become loaded with poison, and the animal precipitated into dangerous disease.

I cannot dismiss this study of the blood without adverting to another refinement in its chemical history, which is intimately connected with the comfortable continuance of animal life. The sensible and chemical changes which it undergoes during its passage over the lungs have been sufficiently explained in a preceding chapter. Driven from the heart to the lungs, it diffuses itself over the cell-walls, passing through the minute blood-vessels, which, like a delicate lace work, every where overspread them. It enters these vessels as dark coloured venous blood. It gives off, as it flows, carbonic acid and watery vapour, and absorbs oxygen gas. It leaves them as bright red arterial blood; and the physiological purpose of this change is, that the warmth of the body may be kept up.

The production of heat in the blood during this passage over the lungs is believed to be nearly in proportion to the quantity of oxygen absorbed; and, as in the burning of wood or coal outside of the body the heat is produced and *becomes sensible* at the spot where the oxygen disappears and carbonic acid and water are formed, so we should expect it to be inside of the body—that is to say, that within the animal the heat should be produced and become sensible in the lungs, because there the oxygen is taken in and the carbonic acid given off.

But were this the case, the lungs should always be at a higher temperature than the rest of the body; and being thus sensibly warmer, much of the heat should be wasted before the flowing blood could distribute it over the distant parts of the body.

To prevent these apparently necessary evils, the blood, as it assumes its bright red colour, is in some unknown way

caused to undergo at the same time a remarkable change in its *capacity for heat.*

By the specific heat of bodies, or their capacity for heat, is meant the comparative quantity of heat which is necessary to raise the sensible temperature of a given weight of any substance a given number of degrees; and I have elsewhere* illustrated this by stating that the same quantity of heat which will make a pound of water warmer by one degree, will make a pound of quicksilver warmer by thirty degrees. This means and shows that water requires thirty times as much heat to warm it up to a certain temperature as quicksilver does. In other words, the specific heat, or capacity for heat, of water is thirty times greater than that of quicksilver.

Now, as the blood passes through the lungs its capacity for heat is somehow increased. It becomes capable of absorbing one-seventh more heat than it already contains, without increasing in sensible temperature.† The average warmth of the blood is about 98° Fahr. We do not know how much heat it quiresac to raise a pound of venous blood to this degree of warmth; but whatever the quantity may be, it acquires at once, by passing through the lungs, the property of absorbing about one-seventh more, without becoming warmer than 98° Fahr. Thus the heat produced in the lungs by the absorption of the oxygen is immediately taken up and hidden, as it were, in the blood. The lungs are not over-heated and inflamed, but the bright red arterial blood becomes a storehouse of concealed warmth, which it carries with it to all parts of the body. In its progress towards the extremities, it gradually loses this large capacity for heat. The warmth previously hid in it gradually becomes

* See THE WATER WE DRINK, p. 27.

† If the specific heat of water be called 1000, that of venous blood is 892, and that of arterial blood 1030, or upwards of one-seventh part more.—CRAWFORD.

sensible, so that, before it returns to the lungs again, it nas imparted, by little and little, to the various remote parts of the body, a large quantity of sensible heat, without itself becoming sensibly colder.

Yet even this beautiful adaptation of the properties of the blood to the general warmth of the animal is not considered enough to secure its healthy and comfortable temperature against all contingencies. Should the blood flow too languidly through the lungs to carry off all the surplus heat naturally produced there, or should too much heat become sensible in the lungs from any other cause, it is expended in the production of watery vapour, and breathed out into the air; or should external warmth or bodily exercise add materially to the natural and necessary heat produced by the internal changes already described, the water of the system again takes it up, and, escaping from the body in vapour, dissipates it through the atmosphere. How abundant the pores or openings are by which an outlet for this vapour through the skin has been provided, I have already shown in a preceding chapter.*

So numerous, so interesting, and so provident are the structural, physical, and chemical arrangements for producing, for storing up, for economising, and for tempering the warmth of the human body!

Not less rich in curious chemical phenomena are the natural cravings of the animal appetite for special kinds of food. The formation of blood, and the maintenance of the animal heat, require the introduction into the stomach of certain chemical forms of matter—gluten, fat, starch, &c., in certain proportions. If for a length of time these proportions be disregarded, first the comfort of the animal suffers, and, subsequently, its health. Such changes often proceed slowly, and become sensible only after many years elapse;

* See WHAT WE BREATHE AND BREATHE FOR, p. 560.

but the feeblest derangements make themselves felt at last, so as seriously to affect the constitutions of whole families and tribes of men.

It is very striking, therefore, to observe how, by a kind of natural instinct, the inhabitants of every country have contrived to mix up and adjust the several kinds of food within their reach, so as to attain precisely the same physiological end. The Irishman mixes cabbage with his potatoes, the Englishman bacon with his beans, or milk and eggs with his rice, and the Italian rich cheese with his maccaroni. So oil or cream is eaten with salad, and butter or oil everywhere with bread. These, and other methods mentioned in previous chapters, exhibit so many purely chemical ways of preparing mixtures nearly similar to each other in composition and nutritive value. In the most rude diet, and in the luxuries of the most refined table, the main cravings of animal nature are never lost sight of. Besides the first taste in the mouth, there is an after taste of the digestive organs, which requires to be satisfied. An indifferent cook may gratify the first; he is no mean physiological chemist who can at the same time fully satisfy the second.

Even the water we drink is an important element in a well-considered and long-adjusted diet. It by no means follows in all cases, perhaps not even in the majority, that the purest water is the best for the health of a given family, or for the population of a given district. The bright sparkling hard waters, which gush out in frequent springs from our chalk and other limestone rocks, are relished to drink, not merely because they are grateful to the eye, but because there is something exhilarating in the excess of carbonic acid they contain and give off as they pass through the warm mouth and throat; and because the lime they hold in solution removes acid matters from the stomach, and thus acts as a grateful medicine to the system. To abandon the

use of such a water, and to drink daily in its stead one entirely free from mineral matter, so far from improving, may generally injure the individual or local health.

And so the nature of the water of a country may even have something to do with the choice of a national diet. The human body, for example, requires a certain proportion of lime to be contained in or mixed with its food. If the common diet do not contain a sufficient proportion of this mineral ingredient, the common water of the country may supply the deficiency; and thus a national mode of living may spring up, the salutary properties of which depend partly upon the food and partly upon the water. In another district or country, where the drinking-water is different, the same solid food, eaten alone, may be unsuited for the maintenance of health.

Ireland presents us with a case in which this state of things appears to exist. The potato has become in a sense the national food of Ireland.* This root contains larger proportions of potash and soda, but much less of lime, and other necessary mineral ingredients, than either wheat or oats, which are the staples of English and Scottish life. But the greater part of Ireland is covered with a broad limestone formation, which inpregnates with lime the springs and other waters employed for domestic purposes; so that the mineral contents of what they drink, supply the natural deficiency in what they eat! In this way it will appear that the reasons for the adoption of a peculiar national diet may lie much deeper than political economy can generally go. It may depend upon refined chemico-physiological and

* In 1854 Ireland grew about 1,000,000 acres of potatoes, and 2,000,000 acres of oats. But suppose all the oats to be consumed in Ireland, which is far from being the case, one acre of potatoes gives more food for man than two acres of oats;† so that the potato is still the prevailing or national food of Ireland.

† See the Author's *Elements of Agricultural Chemistry and Geology*, 6th edit., p. 341.

chemico-geological relations, the discovery of which we may be very long indeed in arriving at.

It is the same with artificial beverages as with articles of ordinary drink and diet. An unthought-of chemical instinct has guided men in the selection of these also. The ancient Abyssinian and the modern Arabian had their coffee—the Chinese and Tartars their tea—the South American aborigines their maté—and the Mexicans their cocoa, ages before any chemical knowledge existed as to the nature of the substances contained in them. What constitutional cravings common to us all have prompted to such singularly uniform results! Through how vast an amount of unrecorded individual experiences must these results have been arrived at!

And so with what we call condiments, similar instincts have their play. The wild buffalo frequents the salt-licks of North-western America; the wild animals in the central parts of Southern Africa are a sure prey to the hunter who conceals himself beside a salt spring; and our domestic cattle run peacefully to the hand that offers them a taste of this delicious luxury. From time immemorial it has been known that without salt man would miserably perish; and among horrible punishments, entailing certain death, that of feeding culprits on saltless food is said to have prevailed in barbarous times. Maggots and corruption are spoken of by ancient writers as the distressing symptoms which saltless food engenders; but no ancient or unchemical modern could explain how such sufferings arose. Now we know why the animal craves salt, why it suffers discomfort, and why it ultimately falls into disease, if salt is for a time withheld. Upwards of half the saline matter of the blood (57 per cent) consists of common salt; and as this is partly discharged every day through the skin and the kidneys, the necessity of continued supplies of it to the healthy body becomes suf-

ficiently obvious. The bile also contains soda as a special and indispensable constituent, and so do all the cartilages of the body. Stint the supply of salt, therefore, and neither will the bile be able properly to assist the digestion, nor the cartilages to be built up again as fast as they naturally waste.

And yet what shows this craving for salt to arise out of a refined species of instinct, similar to that which may have fixed the national food of Ireland, is the fact that neither man nor animals are every where eager for or even fond of salt. Mungo Park describes salt as "the greatest of all luxuries in central Africa." * But the Damaras, in South-western Africa, never take salt by any chance; and even Europeans, travelling in their country, never feel the want of it. "Half of this people lives solely on pig-nuts (?), the most worthless and undigestible of food, and requiring to be eaten in excessive quantities to afford nourishment enough to support life."—(GALTON). Their neighbours, the Namaquas, set no store by salt; the Hottentots of Walfisch Bay "hardly ever take the trouble to collect it;" and even the wild "game in the Swakop do not frequent the salt rocks to lick them, as they do in America." †

In the colds of Siberia, also, as in the heats of Africa, a similar disregard of salt sometimes prevails. "Most of the Russians at Berezov eat their food without a particle of salt, though that condiment can easily be obtained at a trifling cost; a sufficient quantity of it being always kept at the government magazine, and sold at a moderate price.

* "It would appear strange to a European to see a child suck a piece of rock salt, as if it were sugar. This, however, I have frequently seen; although in the inland parts the poorer class of inhabitants are so very rarely indulged with this precious article, that to say a man eats salt with his victuals, is the same as saying he is a rich man. I have myself suffered great inconvenience from the scarcity of this article. The long use of vegetable food creates so painful a longing for salt, that no words can sufficiently describe it."—MUNGO PARK.

† *Narrative of an Explorer in Tropical South Africa.* By FRANCIS GALTON, Esq. P. 183.

Indeed, were the price of salt even much higher, it could make no difference to the wealthier class of the inhabitants, who can so well afford every indulgence, and procure for their table the most expensive luxuries. But salt is not at all in use, and hence I am led to the conclusion that their taste is such as not to require with their food that condiment, which is every where else considered indispensable. Their soups, vegetables, and even roast meats, are prepared and eaten without salt." *

The explanation of these cases, so inconsistent with our general experience, is found in the refined instinct of the body itself. When the food we usually eat conveys a sufficiency of salt into the body, it has no occasion for more. It therefore feels no craving for it, shows no liking to it, and takes no trouble to obtain it. And doubtless, in the kind of food and drink consumed in the Damara country, and by the Russians of Berezov, either more salt than is usual among us is conveyed into the stomach, or their habits render less salt necessary to them, or cause less of it to be daily removed from their bodies.

Nor is the refined delicacy of the instinctive perception of the living body, in this case, more wonderful than that marvellously delicate susceptibility to the influence of minute quantities of matter which we have seen it to be in so many instances capable of displaying. The narcotics which exercise so remarkable a power over us act upon the system in quantities which are inappreciably small. The beverages we prepare exhilarate and strengthen by almost infinitesimal doses of the active ingredients they contain. The odours we enjoy come floating to the nostrils in molecules of inconceivable minuteness and tenuity; while neither by weight nor by measure can we estimate the fatal miasmata which carry fever and plague wherever they penetrate.

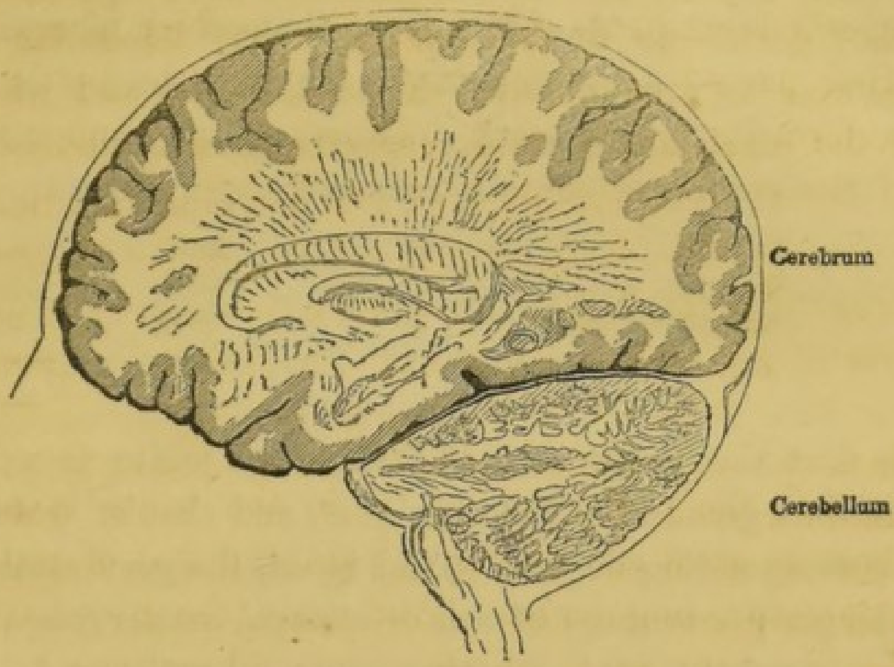
* *Revelations of Siberia.* By a Banished Lady. Vol. ii. p. 195.

Equally delicate and mysterious is the relation which our bodies bear to the passing light. How our feelings, and even our appearance, change with every change of the sky! When the sun shines, the blood flows freely, and the spirits are light and buoyant. When gloom overspreads the heavens, dulness and sober thoughts possess the mind. The energy is greater, the body is actually stronger, in the bright light of day; while the health is manifestly promoted, digestion hastened, and the colour made to play on the cheek, when the rays of sunshine are allowed freely to sport around us.

Want of space forbids me to advert at length to the solid materials of which the most important organs of the body consists. Yet the chemistry of these is every where equally delicate and refined. How wonderful, for example, the varying colour of that soft pulpy gelatinous matter (*corpus papillare*) which rests on the mucous net-work (*rete mucosum*) between our outer and inner skins (see fig. 100). Black in the African negro, red in the North American Indian, yellow in the Asiatic, and white in the European, it gives the characteristic colour to each race of men. It is structurally the same in all, but for wise ends, it differs chemically in each, so as to adapt each race for the conditions in which it is destined to live. And so for other wise ends, no doubt; but among these, to give beauty to the female countenance, the pure white of the European neck changes chemically again, and becomes the bright and blushing rose on the blooming maiden's cheek.

And then the brain, the distinctive organ of the human race, what chemical novelties and peculiarities it exhibits. Cut across the cerebrum, as shown in the annexed fig., 112, it is seen to consist of a mass of white or medullary matter, bordered towards the outer edge by little inlets of a grey substance. In structure these two parts differ. The grey

Fig. 112.



In the above illustration, the shaded parts represent the grey or brown substance of the cerebrum.

matter consists of cells or vesicles grouped together in mass, without any special arrangement. The white portion, again, consists of minute fibres, which proceed from or terminate in the grey matter. Then, as to function, the grey matter, though so small in quantity, is supposed to be the seat of the intellect, and the source of all nervous power. Softenings, tumors, and abscesses, may exist in the white part of the brain; a portion of it may even be extracted without seriously or universally affecting the mental powers; but compress the grey part ever so little, or otherwise alter or disturb it, and you at the same time seriously interfere with the processes of thought, and disturb the intellectual sanity of the individual.

Then further as to chemical composition, the whole brain and nervous tissue is distinguished by containing a large proportion of one or more peculiar fatty matters, in which phosphorus is a characteristic ingredient. And in each important part of the brain and nerves, the proportions of the

several ingredients differ from that which prevails in the other parts—no doubt that each may be better fitted to perform its proper work. Thus the grey and white parts of the cerebrum contain respectively in a hundred parts—

	White.	Grey.
Fat,	20.18	5.96
Water,	71.05	86.26
Albuminous matter,	8.76	7.78
	100	100

So that the proportion of fat in the white is nearly four times as great as in the grey part, and that of water less in a corresponding degree. And again, the grey matter leaves a larger per-centage of ash or mineral matter when burned, and its fatty part contains more phosphorus.* Similar differences also prevail in the proportions of these constituents, both organic and mineral, in different portions of the white matter of the brain itself, and of the numerous nerves, at different periods of life, and when under the influence of different diseases—so that in this marrow-like nervous matter chemical adjustments are to be found as intricate and refined as in any other portions of our bodily economy.

I could have wished also to advert to the construction and chemical composition of the parts of the eye, to the chemical as well as physical adaptation of these several parts to the optical functions they perform, and to the composition and use of the tears by which it is occasionally bedewed;—to the teeth, coated and often interwoven with a flinty enamel of an altogether peculiar nature;—to the fluids that moisten the nostrils and ears, or that flow from the fat cells of the skin, each fluid chemically adjusted to its special work;—and to many other topics of a similar kind connected

* The fatty matter of the grey part contains 2.1 per cent., and of the white part 1.66 per cent. of phosphorus.

with the chemistry of our everyday life. It is sufficient for my present purpose, however, to have shown that the molecular mechanism, so to call it, of the body we cherish, is not less wonderful than its anatomical structure—and that though a little more profound and difficult to comprehend, it is not less worthy of being studied by the intelligent, the cultivated, or the reverential mind.

CHAPTER XXXII.

THE CIRCULATION OF MATTER,

A RECAPITULATION.

Employment of matter for successive uses; popular ideas regarding.—Shakespeare's Hamlet.—Human saltpetre.—The circulation of water.—Ascent of vapour in tropical regions.—Evaporation from the leaves of plants.—Expulsion from the lungs and skin of animals.—Chemical circulation of water.—Circulation of carbon.—Quantity of carbon in the atmosphere; how it is continually renewed.—Decay of shed leaves and bark, and yearly ripening herbage.—Breathing of animals.—Relations of air, plant, and animal, as regards this carbon.—Burying of carbon in the earth; restoration to the air by the burning of coal.—Carbon confined in limestone rocks; how the earth breathes this out again.—Circulation of nitrogen.—Gluten of plants.—Forms in which nitrogen exists in plants, in the soil, and in animals.—Restlessness of matter within the animal body.—Rapid waste of the tissues; agency of oxygen in this waste.—Production of urea; change of this in the soil.—General scheme of the circulation of nitrogen; we cannot restrain it.—How part of the nitrogen escapes, and revolves in a wider circle.

THAT the same portion of matter may, in the operations of nature, be employed for various successive purposes, living and dead, has long been familiar to the popular mind. Philosophers of almost every age have speculated on the changes of matter, and poets have found scope for their imaginations on a subject at once so interesting and so indefinite. It is only from the results of modern scientific investigation, however, that clear and positive ideas have been obtained as to the nature, the necessity, and the connection of these natural changes. We now know not only

that matter does constantly change, but that it constantly circulates in a round of unceasing change. It has been shown that the transformations it undergoes are necessary to the existing condition of things; that they take place in a fixed and predetermined order; and that they are again and again renewed in an endlessly revolving succession.

There is a degree of rude sublimity in the curious reasoning of Hamlet, when he says: "Alexander died; Alexander was buried. Alexander returneth into dust; the dust is earth; of earth we make loam; and why of that loam, whereto he was converted, might they not stop a beer-barrel?

'Imperial Cæsar, dead and turned to clay,
Might stop a hole to keep the wind away.
O that *that* earth which kept the world in awe,
Should patch a wall to expel the winter's flaw!'"

And yet the matter-of-fact touch of modern knowledge turns the whole of this into an absurd conceit. The body of man crumbles into a handful of loose dust, it is true; but this dust is not earth, of which we can make loam to stop a gap or flaw withal; and thus, in the incorrectness of his facts, we forget the merits of the poet.

More might be made by a true poet of the fact related by Mr. Squier, that the Romish priests at Leon, in Nicaragua, sell the burial-ground around their churches, for the use of their occupants, for periods of from ten to twenty-five years; "at the end of which time the bones, with the earth around them, are removed and sold to the manufacturers of nitre." * So that to the unexpected, warlike, and base use of making "villanous saltpetre," are the best and most peaceful of the Nicaraguan citizens yearly converted.

The words of Shakespeare and the fact of Squier may both suggest to us many reflections; but there is nothing

* Squier's *Nicaragua*, vol. i. p. 384.

positive in either of them, beyond the meagre moral, that what forms part of the living, cherished, almost worshipped body to-day, may be employed for most unexpected, and what appear most vile, purposes to-morrow. This limited truth formed the substance of all the ancients knew, and of all the moderns could say, until very recently, regarding the changes and future fate of the animal body after the living spirit had left it. But this branch of natural knowledge has been so wonderfully illustrated by the researches of the present and passing generations, that we can now follow the same particle of matter through a long series of successive visible transformations. To-day we can see it living in the plant, to-morrow moving in the animal; next floating as a constituent portion of the thin air, or rippling along as an ingredient of the clear brook; then resting for a while in the lifeless soil, waiting till the opportunity arrives for its commencing a new career.

It will not, I believe, be without interest to my readers, after perusing the details of the preceding chapters, if I briefly recapitulate in this place the substance of what has been already stated in regard to the changes of matter;—what is the nature of the transformations it undergoes; by what agencies they are brought about; and for what important end. I shall begin with the simple, and advance to the more complicated.

I. The Circulation of Water.—The simplest form of the circulation of matter is that which is presented by the watery vapour contained in the atmosphere. From this vapour the dews and rains are formed which refresh the scorched plant and fertilise the earth. The depth of dew which falls we cannot estimate. On summer evenings it appears in hazy mists, and collects on leaf and twig in sparkling pearls; but at early dawn it vanishes again un-

measured—partly sucked in by plant and soil, and partly dispelled by the youngest sunbeams. But the yearly rainfall is easily noted. In our island it averages about thirty inches in depth; and in Western Europe generally, it is seldom less than twenty inches. Among our Cumberland mountains in some places a fall of two hundred inches a year is not uncommon; while, among the hills near Calcutta, as much as five hundred and fifty inches sometimes fall within six months.

Now, as the whole of the watery vapour in the air, were it to fall at once in the form of rain, would not cover the entire surface of the earth to a depth of more than five inches—(Dr. Prout)—how repeated must the rise and fall of this watery vapour be! To keep the air always duly moist, and yet to maintain the constant and necessary descent of dew and rain, the invisible rush of water upwards must be both great and constant.

The ascent of water in this invisible form is often immediate and obvious, depending solely upon physical causes. But it is often also indirect; and, being the result of chemical or physiological causes, is less generally perceptible. Thus—

1°. Water circulates abundantly between earth and air through the agency of purely physical causes. We see this when a summer shower, falling upon our paved streets, is speedily licked up again by the balmy winds, and wafted towards the region of clouds, ready for a new fall. But, on the greatest scale, this form of circulation takes place from the surface of the sea in equatorial regions, heated through the influence of the sun's rays. Thence streams of vapour are continually mounting upwards with the currents of ascending air, and with these they travel north and south till colder climates precipitate them in dew rain, or snow. Returned to the arctic or temperate seas by many running

streams, these precipitated waters are carried back again to the equator by those great sea-rivers which mysteriously traverse all oceans, and, when there, are ready to rise again to repeat the same revolution. How often, since time began, may the waters which cover the whole earth have thus traversed air and sea, taking part in the endless movements of inanimate nature!

2°. Again, physiological causes, though in a less degree than the physical, are still very largely influential in causing this watery circulation.

Thus the dew and rain which fall, sink in part into the soil, and are thence drunk in by the roots of growing plants. But these plants spread out their green leaves into the dry air, and from numberless pores are continually exhaling watery vapour in an invisible form. From the leafy surface of a single acre in crop, it is calculated that from three to five millions of pounds of water are yearly exhaled in the form of vapour in our island; while, on an average, not more than two and a half millions fall in rain. Whether the surplus thus given off be derived from dews or springs, it is plain that this evaporation from the leaves of plants is one of the more important forms which the circulation of water assumes.

So animals take into their stomachs another portion of the same water, and, as a necessary function of life, are continually returning it into the air from their lungs and their insensibly reeking hides. About two pounds a day are thus discharged into the air by a full-grown man, and larger animals give off more probably in proportion to their size. Multiply this quantity by the number of animals which occupy the land surface of the globe, and the sum will show that this also is a form of watery circulation which, though less in absolute amount than the others I have mentioned, is yet of much importance in the economy of nature.

3°. But water circulates also, in consequence of unceasing chemical operations, in a way which, if less obvious to the uninstructed, is, if possible, more beautiful and more interesting than the mere physical methods above described.

We have seen that the main substance of plants—their woody fibre—consists in large proportion of water. The same is true of the starch and sugar which we eat as food. One hundred pounds of each of these three substances consist respectively of—

	Woody fibre.	Starch and sugar.
Water, ...	55½	60
Carbon, ...	44½	40
	100	100

Now, as the plant grows, water from the soil or from the air unites chemically with carbon, and forms the woody fibre of its stem, the sugar of its sap, and the starch of its seed. When the plant dies and decomposes in the air, the water is again set free from its woody stem. Or when the animal digests the starch or sugar, the water which these contain is discharged from its lungs and skin.

Thus the living plant works up water into its growing substance, which water the decaying plant and the breathing animal again set free; and thus a chemical circulation continually goes on, by which the same water is caused again and again to revolve. Within a single hour it may be in the form of starch in my hand, be discharged as watery vapour from my lungs, and be again absorbed by the thirsty leaf to add to the substance of a new plant.

II. The Circulation of Carbon.—This chemical form of water-circulation will be rendered more clear by tracing the still more beautiful circulation of carbon.

Carbonic acid gas is now familiar to my readers as that sparkling air which, rising in countless bubbles, gives life

to the creaming tankard, to the tempting champagne, and to the more innocent soda water. This gas, as I have already explained, consists of carbon and oxygen only, and is an essential constituent of our atmosphere. It exists, it is true, only in small proportion in the air. Every two thousand five hundred gallons of the air at the level of the sea contain only one gallon of the gas; yet upon the constant presence of this small proportion, the continuance of all vegetable life depends.

This dependence appears more striking to us, however, the more precise our ideas become as to the absolute quantity of this substance which the entire air contains. The whole weight of the atmosphere is about 15 lb. to the square inch, and of this the carbonic forms somewhat less than 120 grains, containing about 33 grains of carbon. Now, living plants are continually sucking in this gas by their leaves; and the operation goes on so rapidly, that were the entire surface of the earth dry land and under cultivation, crops such as we generally reap from it would extract and fix the whole of the carbon in the form of vegetable matter, in the short space of twenty-two years! * Were this to happen, vegetation would cease. But such a catastrophe is prevented by the constant restoration of carbonic acid to the air through the increasing operation of preservative causes. Thus—

1°. The trees of the forest yearly shed their leaves, or in Australia their bark. Through the influence of the weather these waste portions decay and disappear, restoring again to the atmosphere a portion of the same carbon which the living tree had previously extracted from it during the.

* In my published *Lectures on Agricultural Chemistry and Geology*, second edit., p. 262, I have calculated this period at fourteen years. It has recently been discovered, however, that at great heights the proportion of carbonic acid in the air is very much larger than at the sea level. A new calculation, therefore, has led me to extend the period to at least twenty-two years, as given in the text.

period of their growth. The yearly ripening herbage also, and every plant that naturally withers, on plain or hill—the grass of the burning prairie, and the timber of inflamed forests—with all that man consumes for fuel and burns for other uses;—every form of vegetable matter, in short, when exposed to the action of air or fire, returns, more or less quickly, to the state of carbonic acid, and disappears in the invisible atmosphere. Thus, what is yearly withdrawn from the air by living plants is so far restored again by those which naturally perish, or which are destroyed by the intervention of man.

2°. But man himself and other animals assist in the same chemical conversion. They consume vegetable food, with the same final result as when it perishes by natural decay, or is destroyed by the agency of fire. It is conveyed into the stomach in the form in which the plant yields it. The green herb, the perfect seed, and the ripe fruit, are eaten and digested; then forthwith they are breathed out again from the lungs and the skin, in the form of carbonic acid and water. But we can follow this operation more closely, and it will be both interesting and instructive to do so.

The leaf of the living plant sucks in carbonic acid from the air, and gives off the oxygen contained in this gas. It retains only the carbon. The roots drink in water from the soil, and out of this carbon and water the plant forms starch, sugar, fat, and other substances. The animal introduces this starch, sugar, or fat into its stomach, and draws in oxygen from the atmosphere by its lungs. With these materials it undoes the previous labours of the living plant, delivering back again, from the lungs and the skin, both the starch and the oxygen in the form of carbonic acid and water. The process is clearly represented in the following scheme:—

	Takes in	Produces
THE PLANT,	*Carbonic acid* by its leaves; *Water* by its roots.	*Oxygen* from its leaves; *Starch, &c.*, in its solid substance.
THE ANIMAL,	*Starch and fat* into the stomach; *Oxygen* into the lungs.	*Carbonic acid and Water* from the skin and the lungs; *Fat* in the animal's body.

And this fat, laid up for a while in the body, is in its turn also breathed away in carbonic acid and water.*

Thus the circle begins with carbonic acid and water, and ends with the same substances. The same materials—the same carbon, for example—circulates over and over again, now floating in the invisible air, now forming the substance of the growing plant, now of the moving animal, and now again dissolving into the air, ready to begin anew the same endless revolution. It forms part of a vegetable to-day—it may be built into the body of a man to-morrow; and a week hence, it may have passed through another plant into another animal. What is mine this week is yours the next. There is, in truth, no private property in ever-moving matter.

3°. Yet all the carbonic acid which is removed from the air by the agency of plants, is not immediately restored by the circulation above described. Two larger wheels revolve to make up the deficiency.

a. It has been shown that when plants die and decay, are burned in the air, or are eaten by animals, the carbon they contain is delivered back again to the atmosphere in the form of carbonic acid. But all the plants produced yearly over the whole earth are not so resolved into gaseous substances in any given time. In all parts of the world, and during all time, some portions of vegetable matter have escaped this total destruction, and have been buried beneath the surface of the earth, to be preserved in the solid form for an indefinite period. With such comparatively indestructible forms of vegetable matter we are familiar in the

* See WHAT WE BREATHE AND BREATHE FOR.

peat-bogs of Scotland and Ireland—sometimes from 50 to 100 feet deep—and in the submarine forests which are seen in so many parts of our island-shores. We are still better acquainted with them, however, in those vast deposits of coal which a kind Providence, long ago, brought together and covered up. What is and has been thus collected and gradually buried would necessarily cause a constant diminution in the small quantity of carbonic acid contained in the air, were there no natural means in operation for making up the yearly loss.

The means we are most familiar with for repairing this loss, are those which man himself brings into operation. At a certain period in his history, half-civilised man discovered the use of coal. At a more advanced period he found out how to dig deep and hollow out mines in search of it; and, at a still later period, how to employ it for a thousand beneficial purposes. In burning coal, we cause its carbon to unite with the oxygen of the air, and to disappear in the state of carbonic acid. We restore it to the atmosphere again in the state in which it existed there, perhaps a million of years ago, when it was sucked in by the growing plants, and, in the form of vegetable matter, afterwards buried beneath the earth's surface. In raising and consuming coal, therefore, we are, to a certain extent, undoing and counteracting the yearly lessening of the carbon in the air, which appears to ensue from the yearly covering up of a portion of vegetable natter. The two hundred millions of tons of coal which are now yearly consumed throughout the globe, produce about 600 millions of tons of carbonic acid. How far this quantity serves to compensate for what is constantly buried up again, it is impossible to estimate. It must be acknowledged, however, that the coal fires we burn are an important subsidiary agent in promoting the circulation of carbon on the globe.

4°. Again, within the bosom of the great seas, tiny insects are at work, upon which nature has imposed, in addition to the search for food and the care of their offspring, the perpetual labour of building new houses. The common shell-fish of our coasts toil continually for defence as well as for shelter, repairing, enlarging, and renewing their own dwelling-places; and as they die, each drops its shell as a feeble contribution to the beds of shelly limestone which are every where forming at the bottom of our deep seas.

In more southern waters again, still humbler insects build up massive coral walls thousands of miles in extent, which now, skirting long coast-lines, and now encircling solitary islands, bid defiance to the angriest storms. And these, too, as they die, generation after generation, leave, in rocky beds of coralline limestone, an imperishable memorial of their exhaustless labours. These rocks contain, chained down in a seemingly everlasting imprisonment, two-fifths of their weight of carbonic acid. This has been all withdrawn either directly or indirectly from the atmosphere; and thus, through the rock-forming living things it contains, the sea must ever be drinking in, and storing up the carbonic acid of the air.

And the same process has been going on almost continuously since the world began. Vast coral reefs lie buried beneath our beds of coal, and mountains of thick-ribbed shelly limestone have been lifted from ancient seas before these older reefs were formed. The labours of marine animals, therefore, like the burying of vegetable matter, must throughout all time have been causing a daily lessening of the absolute quantity of carbonic acid in the atmosphere,—unless some other natural operation has meanwhile been making compensation for this constant removal.

But the earth herself breathes for this purpose. From cracks and fissures, which occur in vast numbers over the

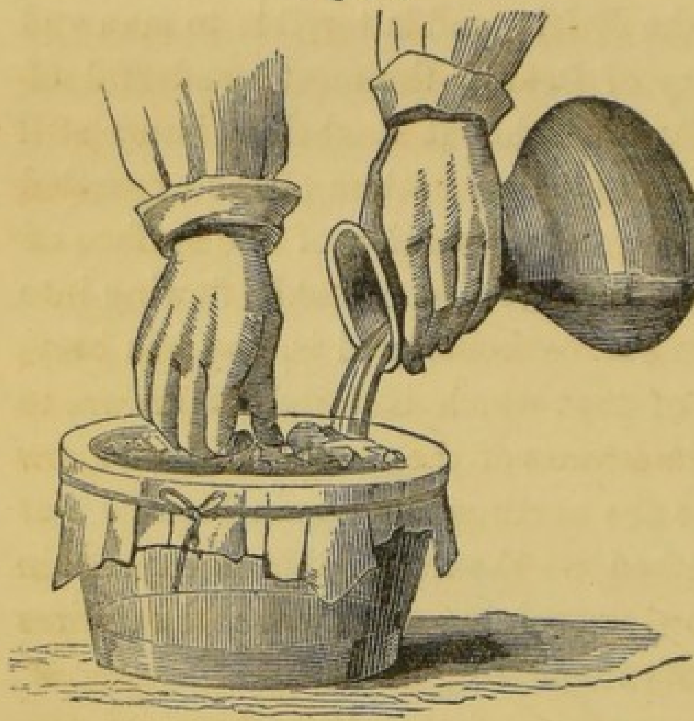
surface of the earth, carbonic acid gas issues in large quantities—sometimes alone, and sometimes along with springing waters—and daily mingles itself with the ambient air. It sparkles in the springs of Carlsbad and Seltzer; rushes, as if from subterranean bellows, on the table-land of Paderborn; astonishes travellers in the Grotto del Cane; interests the chemical geologist in the caves of Pyrmont and among the old lavas of the Eifel; and is terrible to man and beast in the fatal "Valley of Death," the most wonderful of the wonders of Java. And besides, it doubtless issues still more abundantly from the unknown bottom of the expanded waters which occupy so large a proportion of the surface of the globe. From these many sources, continually flowing into the air or rising into the sea, carbonic acid is, and has been, daily supplied in place of that which is daily withdrawn, to be buried in the solid limestones of the globe. Did we know after what lapse of time the earth would again breathe out what is thus daily entombed, we should be able to express in words how long this slowly revolving secular wheel requires fully to perform one of its immense gyrations.

Thus, like the watery vapour of the atmosphere, its carbonic acid also is continually circulating. While that which floats in the air, circles from the atmosphere to the plant, from the plant to the animal, and from the animal to the air again—many times, it may be, during one single generation —never really the property of any, and never lingering long in one stay—the whole created carbon is slowly moving in a greater circle between earth and air. It rises from the earth at one end of the curve in the state of an elastic gas, it amuses itself by the way in assuming for brief intervals many successive varieties of plant-form and animal-form, till it is finally buried in the earth again, at the other end of the curve, in the state of blackened fossil plants, or beds of solid limestone.

III. Circulation of Nitrogen.—We advance now to a circulation a little more complicated in its character, but, if possible, still more interesting to us, because it is more closely connected with our own personal history, both physiological and domestic.

I have already described how, if a portion of wheaten flour be made into dough, and this dough be washed with water upon a sieve, or on a piece of muslin, as long as the water passes through milky, there will remain upon the sieve a tenacious adhesive substance like bird-lime, which is known by the name of gluten; and how, again, if the milky water be allowed to settle, a white powder collects at the bottom, which is common wheaten starch.

Fig. 113.



By this process the flour of wheat is separated into two very different chemical substances,—starch and gluten. Of these two it chiefly consists, and in this respect it is the type of all other vegetable productions which are used as food. They all contain, as their principal constituents, two classes of substances, which are represented respectively by the starch and gluten of wheat. In tracing the circulation of carbon, we have already seen what becomes of the starch of plants when consumed by animals; we are now to follow the changes in which their gluten takes a part.

Gluten is distinguished from starch and fat by containing

nitrogen. This nitrogen is the kind of air which forms nearly four-fifths of the bulk of the atmosphere. It exists also in ammonia,—the well-known compound substance which gives their pungent odour to the liquid hartshorn and smelling salts of the shops,—and in aquafortis, familiar to chemists by the name of nitric acid. These two compound bodies, ammonia and nitric acid, exist and are formed in the soil, and from the soil these and other substances containing nitrogen are taken up by the roots of plants. In the interior of the plant, these substances are subjected to new influences; new chemical changes take place, in which they bear a part; and by means of the nitrogen they contain, gluten is formed. The many intermediate changes which follow each other within the vegetable sap we do not as yet understand; but we do know that the nitrogen which existed as ammonia, nitric acid, &c., in the soil, assumes, after these changes, the final form of gluten within the plant.

And now I have only to recall to the minds of my readers another chemical analogy, to enable them to follow this same nitrogen through still further changes. In treating of the natural relations which exist between animal and vegetable food, I have shown that the fibre or fibrin of the animal muscle and the white or albumen of the egg, are nearly the same thing in composition and general properties as the gluten of wheat. They all contain nitrogen in nearly the same proportion, and probably in a similar state of chemical combination. When the animal consumes vegetable food, therefore, it introduces into its stomach the very substance of its muscles and blood—the ready-formed materials out of which its several parts are to be built up. It does, in fact, so build up and renew its several parts by means of this vegetable substance. The gluten of the plant is transformed into the flesh and tissues of the living animal.

Thus the nitrogen of the soil, through the intermedium

of the plant, has attained to its highest dignity as a part of the body of breathing and intellectual man.

But having attained this most perfect form, the restless elements soon grow weary, so to speak, of their new dignity. Not only is the living body in constant movement as a whole, but all its parts, even the minutest, are in perpetual motion. They are like the population of a great city, moving to and fro, coming and going continually, weeded out and removed hour after hour by deaths and departures, yet as unceasingly kept up in numbers by new incomers;—changing from day to day so insensibly as to escape observation, yet so evidently, that after the lapse of a few years, scarcely a known face can be discovered among congregated thousands. And so rapid is the tear and wear of the animal machine, to change our figure, in consequence of this incessant movement, that the repairs which are constantly called for are said to renovate the whole frame-work in less than a month. Every wheel in that short space is renewed. New materials are brought in for the purpose, while the old are thrown away and rejected.* Scarcely has the gluten of the plant been comfortably fitted into its place in the muscle, the skin, or the hair of the animal, when it begins forthwith to be dissolved out again—to be decomposed and removed from the body. Restlessness, beyond our control, is thus inherent in the very matter of which we are formed.

A brief summary will show how and in what forms this taking down and removal of the bodily substance is so rapidly effected.

The living animal absorbs much oxygen from the air by its lungs. One portion of this oxygen is employed to convert the carbon of a certain part of its food into carbonic acid; another portion is built into the substance of the body itself (p. 565); but a large proportion also is employed in

* See What, How, and Why we Digest.

dissolving out and removing the waste, and now worthless, matter of the muscles and other tissues. This inhaled oxygen is, in fact, the agent through which the change of matter is effected. The muscle, for example, combines with oxygen, and after several intermediate transformations, is finally changed into substances called urea, uric acid, &c., which pass away through the kidneys. This urea and uric acid return to the soil, from which the nitrogen they contain originally came. There they are gradually converted into ammonia, nitric acid, and other substances such as the plant roots originally took up, and which, now re-formed, are ready again to enter into new roots, and thus to recommence the same round of change.

But the animal does not extract and work up all the gluten of the vegetable food it eats. A part of it escapes digestion, and is rejected in the animal droppings. This mingles with the soil, and there, like the urea, &c., is changed into ammonia and nitric acid. The same happens to the gluten of vegetables which die, and, without entering the stomach, undergo direct natural decay in the air or in the soil. Animal bodies themselves die also at last, and, like the vegetable gluten, pass through those successive changes which we call putrefaction and decay. As the result of these changes, the nitrogen they contain is again made to assume those forms in which plants are able to take it up, and to convert it into their own substance.

Thus, after various turns of the wheel, all the nitrogen that entered the plant in the form of ammonia, nitric acid, and similar available compounds, returns again to the soil in one or other of the same states. Some of the matter revolves a time or two less, returning at once from the plant to the soil without passing through the animal at all, or at once from the muscle to the soil without undergoing the ordeal of the kidneys—but whether it runs one, two, or

three heats, all arrives, sooner or later, at the same goal, ready to start again on the same race. A bird's-eye view of this circulation is presented in the following scheme:—

	Takes in	Produces
THE PLANT,	Nitrogen, in the forms of ammonia, nitric acid, &c. from the soil.	Gluten.
THE ANIMAL,	*a.* Gluten into the stomach in its vegetable food, and oxygen through the lungs.	*a.* Muscle and other tissues.
	b. Animal muscle, &c. into the stomach in its animal food, and oxygen through the lungs.	*b.* Urea, &c. in the liquid excretions.
THE SOIL,	Urea, and other animal excretions; dead animals and plants.	Ammonia, nitric acid, and other compounds containing nitrogen.

Thus we end where we began—the soil, the plant, and the animal being involved in one never-ceasing, mutually-dependent revolution. We need scarcely concern ourselves, therefore, for the destiny of the organic part—the tissues and blood of our bodies. Its fate is decided by fixed and unerring laws. When it has served our purpose, new and immediate uses await it. We attempt in vain to detain it from pre-determined labours, or, by the arts of the embalmer, to compel it to perpetuate a loved and honoured form. We need not wait even, as in Hamlet's supposition, for the body to crumble into dust. The fluids and tissues decompose rapidly, and are quickly dissipated, so that what is now part of the body of a Cæsar or a Venus, may literally within a week become part of a turnip or of a potato.

Even here, however, or in respect to this organic form of matter, we obtain occasional glimpses of a still wider circle. While the same portion of matter, on the whole, goes round and round unceasingly, as we have described, a certain portion of the ammonia and other volatile compounds of nitrogen, which are produced by decaying animal and vegetable substances, rises in the form of gas or vapour, and escapes into the air. It rises also in unknown quantity from the lungs and skins of animals, in their breath and perspira

tion. This ammonia the rains of heaven wash out and bring back again to the earth—thus restoring it to the soil from which it originally came, and to the wants of vegetable life. But these very rains also carry down a portion of it directly into the sea, and, through the rivers, sweep it from the land. Yearly, also, a part of the ammonia, nitric acid, and other similar compounds, is by natural operations resolved into elementary nitrogen, and is thus lost to living plants.

To make up for this waste, nitric acid is continually formed in the air in minute quantity. The nitrogen and oxygen of the atmosphere unite to form this acid through the agency chiefly of electric currents, which are continually passing through the air. Ammonia also is given off into the atmosphere from all living volcanoes; and both of these compound substances the falling rain dissolves and carries earthward, so that the failing supplies of nitrogen, in an available form of combination, are continually kept up. Thus, from the great atmospheric reservoir a stream of nitrogen of unknown bulk flows down yearly to the earth in the forms of nitric acid and ammonia, while a similar stream returns again yearly to the air in the form of elementary gas, after having probably many times gone through the cycle of changes in which gluten and fibrin take a part. Within what conceivable time could the nitrogen of the whole atmosphere take part in this slow circulation?

CHAPTER XXXIII.

THE CIRCULATION OF MATTER,

A RECAPITULATION.

Circulation of mineral matter.—General form of this circulation from the soil through the plant into the animal, and thence to the soil again.—Special form.—Circulation of phosphoric acid and of saline matter.—Shedding of leaves and annual decay of vegetable productions.—Course of mineral matter through the animal body.—Waste and death of the body, and its return to the soil.—General view of this circulation.—Its constancy and rapidity.—Vain attempts to preserve human dust apart.—Mummies, pyramids, and Etruscan tombs.—The Valley of Hinnom.—Customs in Thibet and the Himalayas.—How the natural diminution of mineral plant-food is replaced.—Interference of slow geological revolutions.—Lessons taught by all this.—Small quantity of matter on which all life depends.—Lesson of constant, intelligent activity with a view to a definite end.—Purposes served by every movement of matter in living bodies.—How the plant waits upon and serves the animal.—Small change in the condition of things which would banish life from the world.—Man forms no part of the scheme of the universe.—His insignificance the crowning lesson.

IV. THE CIRCULATION OF MINERAL MATTER.—We must now trace the revolutions through which the dust also—the earthy, inorganic, incombustible, or mineral part of the animal—passes.

When a portion of a plant is burned in the air, the organic or combustible part is dissipated, and disappears; but a small quantity of ash or mineral matter remains behind. The wood-ash left when trees are burned is a familiar example of this. In like manner, when any part of an

animal is burned in the air, a portion of ash remains unconsumed. I need scarcely add, that a portion of soil, treated in a similar way, leaves an abundant residue of earthy matter undissipated by the fire.

Now, in regard to the combustible part of the plant—which is made up of carbon, nitrogen, and the elements of water—differences of opinion are possible as to whether the raw materials for building it up are derived from the soil or from the air. They all exist both in air and soil, and may be derived from the one or from the other. But in regard to the mineral or incombustible part of the plant, there can be but one opinion. Mineral matter does not exist in the atmosphere, and therefore the plant must derive all it contains of this kind of matter from the soil in which it grows.

Again, as all which the animal body contains is derived either directly or indirectly from vegetable food, the mineral matter or ash it leaves when burned must have come to it from the soil through the plant. And as, further, when the animal dies, its body is sooner or later returned to the soil, we have again another complete cycle, in which the earthy matter of living things is the ever-moving body. It ascends from the soil into the substance of the plant, thence into the substance of the animal, and thence descends again into the mother earth, to begin, as in our other examples, a new and similar career.

But a more minute chemical examination of this mineral or earthy matter will make our acquaintance with this cycle still more interesting and instructive.

It is not any kind of earthy matter, indifferently, which the plant-root sucks up and builds into the substance of its growing stem and leaves. It selects, as it were, only the rarer and more precious materials of which the soil consists, and from among these again, such as natural waters can more or less readily dissolve. Phosphoric acid, lime, magnesia,

and certain kinds of saline matter, of which we may take common salt as the representative, are the most important of these substances. Generally speaking, these ingredients exist but sparingly in the soil. The productiveness of a tract of land, therefore, in so far as it depends upon their presence, is kept up either by a constant natural circulation of the same quantity of these matters, or by the addition of periodical supplies from some other source, equal in kind and amount to those which the yearly herbage carries away.

In uncultivated regions the natural circulation is short and simple. In natural forests, for example, where the leaves or bark are annually shed, and the trees periodically die, the mineral matter quits the soil for the plant as it grows, and again, when the plant decays, returns to the soil. It thus makes but a short stage from the earth to the plant, and from the plant back to the earth again. It is so also in natural meadows. Yearly, in autumn, the grass ripens, withers, and returns its mineral matter to the soil, and yearly, again, in spring, the young herbage grows up and feeds on the relics of the previous year.

The circulation, though less direct, is not much more protracted when the vegetable produce, as in cultivated regions, is almost entirely consumed by animals. It then enters into their stomachs, is dissolved or digested, and converted into blood. From this blood its several mineral constituents are taken up by vessels provided for the purpose, to be conveyed to the parts of the body where their services are required. The saline portion is retained by the blood and the tissues. The phosphoric acid in combination with lime, forming phosphate of lime, is chiefly deposited in the bones, and in combination with potash, as phosphate of potash, in the muscles.

The importance of the former of these compounds—the phosphate of lime—to the animal economy, becomes appar-

ent when it is recollected that dry bones leave, on burning, two-thirds of their weight of a white ash, of which five-sixths consist of phosphate of lime. But its comparative importance appears still more manifest when we consider how large a proportion it forms of the whole mineral matter of the body. Thus, in a full-grown man,

The whole mineral matter is about . .	10·111 lb.
The phosphate of lime about . .	8
And the other mineral matters, of which common salt forms more than a half, . .	2·111 lb.

But though the mineral matter of the vegetable, when introduced into the animal's stomach, is thus distributed to different parts of the body, and for the most part becomes fixed, as it were, for a time in its most solid parts, this does not necessarily imply any tardiness of circulation. For, as we have already seen, all the parts of the body, even the most solid, are in a constant course of alteration and renewal. To this law of change the bones are subject equally with the softest parts, so that the phosphoric acid and lime which are carried into them by the blood and built into their substance to-day, are, a few days after, taken down and carried out again, along with the other refuse and waste materials of the body. And forthwith, as fast as they reach the soil, these mineral substances commence a new career.

Finally, the whole body dies at once, and all the mineral substances which it at the time contains, return directly to the earth from which they came. There they undergo, chiefly through the agency of the air, a final breaking-up or decomposition, by which they are again brought into states of chemical combination, in which they can enter usefully into the roots of plants.

Thus, all which the plant took from the soil, the animal —partly as it wastes, and partly when it dies— returns to the soil again without any long delay. New plants are thus

at liberty to work up again the old materials, and to despatch them forthwith on a new voyage. This general succession of changes undergone by the mineral matter, which takes a part in the established order of vegetable and animal life, is briefly represented in the following scheme :—

	Takes in	Produces
THE PLANT,	Phosphoric acid, lime, common and other salts, from the soil.	The perfect substance of plants (from organic and mineral substances together).
THE ANIMAL,	*a.* The parts of plants as food. *b.* The bone and tissues of its body, with oxygen through the lungs.	*a.* Perfect bone, blood, and tissues. *b.* Phosphates and other salts in the excretions.
THE SOIL,	Excretions of animals, dead animals, and plants.	Phosphoric acid, lime, common salt, &c.

It may be that a careful hunter after human dust might scrape together as much of what thus returns to the soil as would "stop a hole to keep the wind away." But our chemical science teaches us that this animal earth is not the kind of stuff that plastic clays are made of, and that such vile uses are after all only imaginary slights, to which our cherished ashes can never be subjected. They have other appointed uses, from which, treat them as we may, they cannot long be withheld.

The plant, on the one hand, is so wonderfully framed, that it refuses to grow unless it can obtain the phosphoric acid, &c., which it is bound to gather up and supply to the growing animal. And the soil, on the other hand, is so poorly provided with these and other most needful substances, that plant and animal are both ordained to return without fail their borrowed materials to mother earth, when the term of their own lives has come. A duty is laid also upon each particle of matter, zealously to prepare for a new service as soon as each earlier commission is performed. Thus, a constant circulation of the same comparatively small quantity of mineral matter is secured. Thus, also, we can claim no personal property in any single atom of it.

How idle it seems, then, to the cold chemical eye to cherish either affection or reverence for dead ashes! Do as we may, they can never long be prevented from connecting themselves with new forms of vegetable and animal life, in which we have no concern.

And how visibly rapid, in the majority of cases, is the passage of this substance of our bodies to new forms of life. Thousands yearly perish in the sea, and are at once swallowed, digested, and built into the forms of marine animals. Thousands more die and decay in waste places, where vegetable forms soon cover and feed upon them. Armies of fighting men strew, as they march over a thousand fields, the relics of their wasting strength. A single battle restores to the soil of a populous district, materials enough to build up the bodies of its inhabitants for many succeeding generations.

Nor do grave-yards hold it more securely. Of how many bygone men and women has the mineral substance lived anew in the village sheep which crop the green herbage of the tufted tombs! In how many affection-tended, ornamental cemeteries does the dust of those we loved fatten the soil for the cherished trees and shrubs? And how long is the consecrated ground itself secure against the changes of successive times—the demands of new roads, new streets, new railways, and new sanitary enactments, or the still more ruthless innovations of religious and political revolutions!

Or embalm the loved bodies, and swathe them, as the old Egyptains did, in resinous cerements, and you but preserve them a little longer, that some wretched, plundering Arab may desecrate and scatter to the winds the residual dust. Or jealously, in regal tombs and pyramids, preserve the forms of venerated emperors and beauteous queens, still some future conqueror, or more humble Belzoni, will rifle the most secure resting place. Or bury them in most sacred

places, beneath high altars, a new reign shall dig them up and mingle them again with the common earth. Or, more careful still, conceal your last resting-place where local history keeps no record, and even tradition cannot betray you, then accident shall stumble at length upon your unknown tomb and liberate your still remaining ashes.

How touching to behold the vain result of even the most successful attempts at preserving apart, and in their relative places, the solid materials of the individual form! The tomb, after a lapse of time, is found and opened. The ghastly tenant reclines, it may be, in full form and stature. The very features are preserved—impressed, and impressing the spectator with the calm dignity of their long repose. But some curious hand touches the seemingly solid form, or a breath of air disturbs the sleeping air around the full proportioned body—when, lo! it crumbles instantly away, into an almost insensible quantity of impalpable dust!

Who has not read with mingled wonder and awe of the opening, in our own day, of the almost magical sepulchre of an ancient Etrurian king. The antiquarian *dilettanti*, in their underground researches, unexpectedly stumbled upon the unknown vault. Undisturbed through Roman and barbaric times, accident revealed it to modern eyes. A small aperture, made by chance in the outer wall, showed to the astonished gazers a crowned king within, sitting on his chair of state, with robes and sceptre all entire, and golden ornaments of ancient device bestowed here and there around his person. Eager to secure the precious spoil, a way is forced with hammer and mattock into the mysterious chamber. But the long spell is now broken—the magical image is now gone. Slowly, as the vault first shook beneath the blows, the whole pageant crumbled away. A light smoky dust filled the air; and, where the image so lately sat, only the tinselly fragments of thin gold remained, to show that the vision and

the ornaments had been real, though the entire substance of the once noble form had utterly vanished.*

For a few thousand years some apparently fortunate kings and princes may arrest the natural circulation of a handful of dust. But in what are they better than Cromwell, whose remains were pitilessly disturbed—than Wycliffe, whose ashes were sprinkled on the sea—than St Genevieve, whose remains were burned in the Place de Grève, and her ashes scattered to the wind—than Mausolus, whose dust was swallowed by his wife Artemesia—or than the King of Edom, whose bones were burned for lime—or than St Pepin, and all the royal line of Bourbon, whose tombs were emptied by a Parisian mob? † Their ashes too are

* See DENNIS's *Ancient Etruria*. The fragments of the gold ornaments are in the collections of Lord Kinnaird at Rossie Priory.

† "They burnt on the Place de Grève the remains of St Genevieve, the popular patroness of Paris, and threw her ashes to the wind. . . . A decree of the Convention had commanded the destruction of the tombs of the kings at St Denis. The Commune changed this decree into an attack against the dead. . . . The axe broke the gates of bronze presented by Charlemagne to the Basilica of St Denis. . . . They raised the stones, ransacked the vaults, violated the resting-places of the departed, sought out beneath the swathings and shrouds, embalmed corpses, crumbled flesh, calcined bones, empty skulls of kings, queens, princes, ministers, bishops. Pepin, the founder of the Carlovingian dynasty, and father of Charlemagne, was now *but a pinch of grey ash, which was in a moment scattered by the wind.* The mutilated heads of Turenne, Duguesclin, Louis XII., Francis I., were rolled on the pavement. . . . Beneath the choir were buried the princes and princesses of the first race, and some of the third—Hugues Capet, Philip the Bold, Philip the Handsome. They rent away their rags of silk, and threw them on a bed of quicklime. . . . They flung the carcass of Henry IV. into the common fosse. His son and grandson, Louis XIII. and XIV., followed. Louis XIII. was but a mummy; Louis XIV. a black indistinguishable mass of aromatics. Louis XV. came last out of his tomb. The vault of the Bourbons rendered up its dead—queens, dauphinesses, princesses, were carried away in armfuls by the workmen, and cast into the trench." —LAMARTINE, *History of the Girondists*, book lii. § 23. A brief interval of proud separation, and they were mingled with the common dust!

From all this desecration only the remains of Turenne escaped. Rescued by a patriotic admirer from the hands of the destroyers, they were at first concealed in an obscure corner of the Jardin des Plantes, and afterwards consigned to the care of M. Alexandre Lenoir, among other curiosities he had collected in the museum of the Petits Augustins. In September 1799 they were transferred from this place by Napoleon, then consul and a conqueror, to a splendid tomb prepared for them be-

dissipated at last. Their empty tombs may remain—the houses of the dead, like the houses of the living, long surviving, as melancholy mementoes of the tenants for whom they were erected.*

There is a barbaric philosophy, therefore, as well as an apparent knowledge of the course of nature, in the treatment of the dead which prevails in Thibet and on the slopes of the Himalaya. In the former country the dead body is cut in pieces, and either thrown into the lakes to feed the fishes, or exposed on the hill-tops to the eagles and birds of prey. On the Himalayan slopes the Sikkim burn the body and scatter the ashes on the ground. The end is the same among these tribes of men as among us. They briefly anticipate the usual course of time—a little sooner verifying the inspired words, "Dust thou art, and unto dust thou shalt return."

There remain now only one or two other observations to complete our history of the revolutions of mineral matter.

Notwithstanding the constant return of plant and an-

neath the dome of the Invalides, and there deposited with much state—"where," says M. Thiers, "the body now reposes, and where it was soon to be rejoined by his companion in glory, the illustrious and virtuous Vauban, where he was destined to be joined one day by the author of the great things we are here relating; where he will certainly remain, surrounded by this august company, throughout the ages which Heaven may reserve for France."

How rash this prophecy of the illustrious historian, all past history may testify. (See also ALISON'S *History of Europe*, and Sir THOMAS BROWN *On Urn Burial.*)

* How suggestive are the following remarks of M. de Saulcy on the rock-tombs of the valley of Hinnom:—"The immense necropolis, traces of which are to be met with at every step in the v aley, dates from the period when the Jebusites were masters of the country. After them the Israelites deposited the remains of their fathers in the same grottoes; and the same tombs, after having become at a still later period those of the Christians who had obtained possession of the Holy City, have, since the destruction of the Latin kingdom of Jerusalem, ceased to change both masters and occupants. Even the scattered bones are no more found in them; and from the city of the dead the dead alone have disappeared, while the abodes are still entire."—DE SAULCY'S *Journey Round the Dead Sea*, vol. ii. p. 253.

imal to the parent earth, all the mineral matter they contain does not remain where they are deposited. Rains and rivers daily remove from the soil a portion of the materials which are so essential to the perpetuation of animal and vegetable forms, and transport them to the sea. Thus the natural store of mineral food becomes daily smaller, and the land, in consequence, less fitted for the growth of plants.

But for this contingency also there is a provision. The solid rocks which form the crust of the earth contain all these essential forms of inorganic matter in minute proportion. As these rocks crumble and mingle with the soil, they yield constant small supplies of each ingredient—of phosphoric acid, lime, magnesia, &c. These the springs which trickle through the rocks from above or from beneath, dissolve and diffuse wherever they go. Thus, in many localities, a moderate supply is day by day brought to the surface-soil, to replace that which, by natural causes, is constantly removed. And the great seas help in this work of restoration. They heave their lofty waves into the air and break in foam, that the rough wind may take up and bear back again to the land a portion of the salty spoils with which the rivers are ever enriching them.

And then, lest these small daily restorations should not succeed in perpetually maintaining the necessary richness of the soil in mineral plant-food, periods of convulsion come at last to their aid. Great physical revolutions from time to time intervene. Now all at once, and now by slow degrees, the bottom of the sea becomes dry. Land and water change places, as they have often done during the geological history of the globe. And after each change, new races of plants forthwith begin to take up what rivers and rains had carried down into former sea-beds. The same mineral matter begins to play over again the same part as before, in the constant succession of animal and vegetable life! In this

we see another long cycle through which certain ingredients of the solid earth are ever slowly moving.

Thus all the varieties of matter which are essential to the existence of living forms are in a constant state of circulation. Each has its appointed round of duty, at one point or other of which it is sure to be found. And while the motions of all the wheels are prescribed, and a restless activity imposed on every particle of matter, all contingencies are guarded against which might interfere with the final accomplishment of the one simple design.

How profound, yet how interesting and intelligible, is all this! How instructive the lessons it reads us! Thus—

1°. On how small a quantity of matter, for example, does it show us that all life depends. Over and over again, as the modeller fashions his clay, plant and animal are formed out of the same material. Over and over again it is transformed in the earth and in the air, as soon as it has been liberated for a time from the domain and dominion of life. In the face of this clear knowledge, how crude, how untrue to nature, how irrational, how misleading are the views which some have promulgated with regard to the final resurrection of man! As if the same matter which forms our body, when we are laid in the grave, and which, after a brief residence there, makes its way, through some nutritive plant, into the body of another man, and forms part of his body still when *he* is buried—as if this matter, which is neither his nor mine, has already "been slave to thousands," and may be buried with ten thousand bodies more, before the resurrection comes—as if this very matter were meant to form the clothing of the disembodied spirit, when, in visible form and sensible identity, it shall be raised on the day when "small and great" appear before the dread tribunal!

The words of the passage, "It is sown a natural body, it is raised a spiritual body;" and of this one, "The dead shall

be raised incorruptible;"—these alone should be sufficient to deter the theological expositor from propounding ideas so gross in regard to the changes we are to undergo at that mysterious time. That which is formed of matter, *such as circulates in living beings now*, can neither be a spiritual body, nor free from the changes which are commonly implied by the word corruption.

2°. Again, the moral lesson is not unimportant which this steady but unceasing movement of the material particles of living bodies holds up to us. No stoppage long hinders it. No delay diverts its attention or causes it to forget its duty. Like the stone which we suspend in the air, it is ready to drop the instant the cord snaps by which it is upheld. Is all senseless matter to be thus perpetually labouring,—and are we intelligent beings to idle away a precious but limited life? To work while we live, is one of the moral lessons which the chemist reads in the movements, so plain to him, in apparently dead rocks and earth and air, not less than in the lifeless bodies of the animal and the plant.

3°. But they teach him also to work steadily and with a view to a definite and useful end. In contemplating the moving wheels I have one after another introduced to my readers, they must have felt inclined to stop and ask respecting each, "Why does this wheel turn? Why its unceasing restlessness? What purpose is effected, or is intended to be effected, by its endless revolution?" Generally the answer is, that the maintenance of life, animal and vegetable, depends, as in a complicated piece of mechanism, upon the perpetual movement of all the wheels at once. In detail, the special answer is, that the turning of each wheel determines the comfortable discharge of one or more of the necessary functions of animal and vegetable life.

When, for example, the plant seems only to be amusing itself in forming starch and vegetable fat from carbonic acid and water and the animal, in merely undoing what the plant

has done—re-converting the starch and fat again into carbonic acid and water—an unseen effect is being produced at the same time, which is indispensably necessary to the continuance of animal life, as it is now constituted. The change which the starch and fat undergo in the animal body—as well as the final change which the gluten consumed by the animal undergoes—is a kind of burning. The heat produced by this burning is imparted to the body and keeps it warm; and the necessity of such internal warmth to the maintenance of animal life is familiar to every one. This wise purpose, therefore, is served, by the way as it were, while the little wheel is turning by which carbonic acid and water alternately disappear in starch and fat, and alternately appear again in their gaseous and liquid forms. And so, were we curiously to inquire what physiological or other effects are produced during the turning of any other of our wheels, either great or small, we should see good coming out of each—a beneficent provision for the comfort of living animals, or for the healthy growth of vegetable forms, accompanying the sensible and chemical results of each revolution In this the chemist reads the lesson that his ever-moving activity should have reference to a definite and good end.

4°. It is especially beautiful, as well as interesting, to see how clearly the consideration above presented exhibits the plant as the servant of the animal. Man placed upon the earth, without the previous existence of the plant, were utterly helpless. He could not live either upon the earth or upon the air, and yet his body requires a constant supply of the elements contained in both. It is the plant which selects, collects, and binds together these indigestible materials, manufacturing them into food for man and other animals. And these only throw back again to their toiling slaves the waste or dead materials which they cannot further use, to be worked up by them anew into palatable and nutritious food. In this aspect, the plant appears only as the appoint-

ed bond-servant of the animal; and yet, how willing, how beautiful, how interesting a slave it is! It works unceasingly, yet it is self-tasked. It toils itself to death, yet, punctually as spring comes round, it rises again in a new life—young, beautiful, and willing as ever, rejoicing to renew its destined toil. There is in it none of the bitterness of human slavery to render the task unsweet. In this, too, there is a lesson for us.

5°. And it is not the least striking of the reflections to which this subject leads us, that an alteration in the natural constitution of things of so small a kind as to be inappreciable to our senses, would at once insure the certain extinction of animal and vegetable life. Let the All-powerful order that the minute proportion of carbonic acid in the atmosphere should be removed, and in a single hour vegetation would droop—in a single week, probably, not a plant would remain alive on the whole face of the dry land! And yet the human organs would perceive no change in the nature of the atmosphere, and the mass of mankind would first wonder at the fatal plague which had so suddenly stricken all vegetable forms, and after a brief period of stupefied and undefined dread, they, too, would perish as the plants had done, for want of sustenance,

6°. This thought again leads us to the contemplation of those purely mechanical motions in which the heavenly bodies continually exercise themselves, without, as a consequence, undergoing any sensible chemical change of matter. On first becoming acquainted with the chemical revolutions of matter above described, we might be inclined—indeed it is a very natural first-sight question—to ask, What have these earthy revolutions which concern us so much—what have they in common with the majestic movements of satellites and planets in their orbits, and with that of systems in the ethereal space? What part do these lesser revolutions —annual many of them, like that of the earth round the sun

—what part do they play in the system of the universe? The humbling answer is, that they take no sensible part in them at all.

The supposition of an insensible removal of the carbonic acid of the atmosphere, and a consideration of its consequences, show that the existence of life, either vegetable or animal, is not a necessary condition of things even on our globe. With an atmosphere so changed the earth might roll on in its place in the solar system—its attendant moon still encircling it—for countless ages, without the change deranging, or even altering in any degree, the most insignificant phenomenon which is nightly seen in the starry heavens. Earthly life, therefore, has no share in the general system of the universe. It is a little episode, so to speak, in the great poem of creation. The Deity willed that this corner of His vast work should be the theatre of new displays of wisdom, of consummate contrivance, of a wonderful fitting-in of means to the accomplishment of beneficent ends, and at last the seat of an intellectual being, with capacity to study and comprehend and admire His works—to praise, and love, and serve Him. It is solely on this seemingly separate act of His will that we depend "for life, and breath, and all things."

And in thinking over this insignificance of man, and all his contemporary forms of life," how awful does it appear, that, in the event of a necessity arising, all this life could be stopped at once—by the simple turning of a screw, as it were—and that the disappearance of all our race would, to the physical universe, be of as little moment as the crushing of the tiny insects, to which all the world they know is but a drop of water!—This is the crowning lesson of all.

INDEX.

THE END.