the peculiar qualities of lacquer make it seem worthy of more consideration than it has received in this country. It gives a surface to wood much harder than our best copal varnish, without brittleness. It takes a polish not to be excelled, which lasts for centuries, as may be seen in the old treasures of Japan. It is proof against boiling water, alcohol, and, indeed, it seems to be insoluble in every agent known. It is the best possible application for laboratory tables. I have a set of photographer's developing trays that have been in use for more than a year, and I find them excellent and cheap. In Japan it is used for many household articles.

A very serious objection to the use of lacquer in this country is the danger of lacquer-poisoning from the fresh material. I have recently heard of a piano-maker who tried to use it, but it affected his workmen so seriously that he was obliged to give it up. The Japanese are very much in dread of the poison, as I found when I tried to get some of my students to accompany me as interpreters to the places of manufacture. Those who are subject to the poison suffer precisely as patients afflicted by the *Rhus*, or poison-ivy. Of course, those engaged in lacquer-work are not affected by it; but whether one acquires immunity after a time, I am unable to tell. However, if the poison is a volatile acid, it would seem possible to remove it by a heat that would leave the lacquer uninjured, and thus make it available for use in this country.

THE PRODUCTION OF SUGAR.

BEFORE proceeding to describe the processes adopted for the extraction and refinement of sugar, says Ward Coldridge, in a sequel to an article on the same subject reprinted from *Knowledge* in *Science* of Aug. 30, it will be advisable to explain the difference between what a chemist means when he speaks of "a sugar" and what people generally understand by sugar. The chemist uses sugar as a generic term, and includes under it — strange as it may seem — things which have no sweetness, and excludes the sweetest of all substances, the newly discovered saccharine. He subdivides his sugar into two classes, — first, true sugars, which are distinguished by their power of undergoing alcoholic fermentation; and, secondly, bodies which do not suffer fermentation. Recent research has diminished the number of substances of the second class, so that for the purpose in hand this class can be eliminated, and our attention can be fixed on the first group only. These fermentable substances which yield alcohol are typically represented by grape sugar and cane sugar. Now grape sugar is less sweet than cane sugar, and its chemical constitution is different. Grape sugar has the formula $C_6H_{12}O_6$; that is, its molecule contains six atoms of carbon, combined with twelve of hydrogen and six of oxygen. When suitably treated with yeast, it ferments, and forms alcohol, and evolves a part of its carbon and oxygen as carbonic acid, one of the two substances from which the plant originally began to form its sugar. The equation is,

$$\underset{\text{Grape sugar}}{C_6H_{12}O_6} = \underset{\text{Alcohol}}{2\,C_2H_6O} + \underset{\text{Carbonic acid.}}{2\,CO_2}$$

It will be remembered that the plants originally formed their sugar from water and carbonic acid; and now it can be understood that Nature, when she wishes to dispose of an excess of sugar, transforms it into alcohol and carbonic acid. There is thus a reversion to the original type: —

$$\left.\begin{array}{c}\text{Water}\\ \text{and}\\ \text{Carbonic acid}\end{array}\right\} \longrightarrow \text{Sugar} \longrightarrow \left\{\begin{array}{c}\text{Alcohol}\\ \text{and}\\ \text{Carbonic acid}\end{array}\right.$$

But alcohol takes the place of water. In the face of the wide difference between the actions of water and alcohol on humanity, it may seem absurd to say that the final products bear any resemblance to the original. Yet, in spite of the physiological difference, the chemical relation of alcohol to water may be summed up in the statement that alcohol is water in which one of the two hydrogen atoms are replaced by a group of carbon and hydrogen atoms, "C_2H_5." Thus,

Water .... $H.\ OH$
Alcohol .... $C_2H_5.\ OH$

Nature does not, however, desire to flood the world with alcohol, for she very quickly transforms it, by aid of a countless army of minute living organisms, into vinegar; and thence, in turn, she passes back to what she started from, — to water and carbonic acid. So the cycle of changes runs on; in all stages it is always proceeding.

The conversion of common sugar is not so direct. Cane sugar must drink water before it can form alcohol. But the draught of water acts on it chemically, and converts this form of sugar into two others, one of which is uncrystallizable. When the sugar becomes thirsty at the temperature of the West Indies, it absorbs water with greater eagerness, and as a result a quantity of molasses or treacle is formed.

The older method of extracting the sugar — and in future in this paper the word will be used in its commercial sense only — was to take the canes which had been cut off as near the roots as possible and stripped of their leaves, and to crush them. From the crushed canes the juice exuded. This juice held in solution, besides the sugar, various substances of an albuminoid nature containing nitrogen, and of mineral bodies chiefly that phosphate of lime ($Ca_3 2PO_4$) which is obtained from bones. The object of the process is to remove these foreign substances, so as to have command of a comparatively pure solution of sugar in water. The albuminoids must be removed as quickly as possible, for they soon begin to assert their presence by causing fermentation in a manner analogous somewhat to yeast. The plan adopted is to collect the juice in large tanks, and then to add a small quantity of lime. The liquor is next heated to a suitable temperature; a thick scum forms on the surface. When it is considered that this coagulation of the albuminous substances has proceeded far enough, the clear liquor is drawn off from below. From this solution the manufacturer desires to obtain as much sugar as possible by crystallization. He therefore boils off the water quickly in open copper vessels, and incidentally improves the purity of his product by removing such scum as may form. The thick sirup which remains is run into coolers and allowed to stand until no more sugar-crystals separate. Finally he places the magma of crystals, and the mother-liquor from which the sugar has separated, into casks with perforated bottoms. The uncrystallizable thick brown viscid mother-liquor which draws away is the common molasses or treacle which is chiefly used in the manufacture of rum.

The process which has been thus outlined is far from being economically perfect. In fact, it is extravagant and wasteful. To begin with, the mechanical contrivances generally used by the colonial sugar-planter for crushing his canes are not perfect: he might obtain more juice from a given weight of cane. A somewhat recent invention seems to have a future before it in this direction. The principle is very simple and well known. It utilizes the fact that a body, when rapidly whirled around, will fly off tangentially unless restrained. The machinery is here so arranged that the juice may escape, but the solid pulp is restrained, and at the end of the operation is left in a dry condition.

However, the most serious defect of the above process arises in the actual manner of working up the comparatively pure sugar solution. Above it was said that the manufacturer rapidly boiled off the water; of course economy of time is an element to be considered. Allowing, then, that the water is removed quickly, it may seem at first sight that the process is excellent. But as a fact it is very wasteful. Why it should be so will be understood by realizing the fact that at the temperature used the water is not merely evaporated, but that some enters into combination with the cane sugar and converts it into grape sugar, as given above, and in the final result a large proportion of molasses is formed. So the question has been considered whether it is possible to remove this water under such conditions as will prevent, or at least diminish, the chemical change. The answer has been an affirmative one. The liquor, instead of being concentrated by boiling down under atmospheric pressure, is now heated in vessels from which the air can be exhausted. Consequently, according to the well-known connection between the temperature at which water boils and the pressure on its surface, the temperature of ebullition in a vacuum will be much lower than in air; the sugar solution will thus be kept while concentrating at temperatures below that at which it readily drinks water, and becomes in part uncrystallizable.

At the present time the colonial sugar manufacturer is proving himself to be a man of strong conservative habits, and very slow to recognize the great practical improvements which have taken place. But the day must come, and that quickly, when the exigencies of competition will lead him to adopt artificial advantages which have proved of service to the continental producer of sugar from beet-root. Then, perchance, the prediction of the Brazilian commission, quoted in the former article, will be verified.

The methods employed for the extraction of the raw sugar from the beet are practically the same as for raw cane sugar; but the impulses towards change and improvement, and the necessity for the rapid evolution of more economic manipulation of details, have led to the foregoing inventions.

One new process, however, has been invented which so strikes at the root of the old process that it merits a description by itself. Instead of crushing the beet-root to a pulp, and then extracting the sugar juice together with albuminoid and gummy matters, it aims at removing the sugar without these foreign substances, and so avoids the subsequent labor for their removal. The beet is cut into slices, and these are washed with water. It is claimed that the sugar diffuses out through the walls of the unbroken cells, whereas the albuminoids and the gummy matters of far greater molecular complexity cannot so escape. When the washing is carried out systematically, the process works exceedingly well. Again, the principle of this improvement, like those which underlie the others, is quite old. The walls of the unbroken cells are perforated with fine pores. The particles of sugar can pass through, but the bulky albuminoid aggregates cannot pass. It is like a sieve at work on a minute scale: sugar for the fine gravel, albuminoids for the stones, gummy matters for the lumps of clay, and the minute pores for the holes of the sieve. The originality consists in the application. The same plan has been used over and over again to detect arsenic in a viscous mixture of substances; the mixture is merely boiled with dilute hydrochloric acid, and then floated on a parchment membrane on a vessel of water, the arsenic passes through into the water, and the filth with which it was mixed remains behind. This diffusion-process, which thus owes its birth to the experiments of the Englishman Graham, is much used on the continent, and its applicability to the production of sugar from the sorgho grass is a source of confidence to those who are trying to develop this new American industry. The sugar trade at this moment watches with interest the practical experiments which are now being made, with, as far as can be judged at present, satisfactory results on its application to the extraction from the sugar-cane. Even in Japan an effort has been made to utilize it, and the government have aided the industry by a bounty, and have, it is said, a considerable share in a large manufactory which is now being floated; here, too, the Japanese evince their keenness in adopting Western inventions, and even in extending European ideas.

But the manufacture of sugar does not end with the production of raw sugar; in England it commenced with the raw sugar. The refining of sugar chiefly consists in the removal of the coloring matter which adheres to the small crystals of the raw sugar, and the casting of the purified crystals into moulds. The same processes are applied both to the raw material from the cane sugar, which is pleasant to the taste, and to that from the beet, which smells unpleasantly and is uneatable. The method is the same as a chemist would adopt, who, in the course of an investigation, prepared a substance which he wanted in a state of perfect purity. The sugar is dissolved, and the solution filtered to remove mechanical impurities. The solution by its tint shows the presence of coloring matter, which is removed by filtering through animal charcoal, when it will filter from the charcoal in a colorless condition. It is a curious experiment to shake a wine-glass of port wine with some finely divided animal charcoal; after filtering, the wine is obtained as colorless as water, but it completely preserves all its characteristic properties of taste unaltered. The colorless solution of sugar is then concentrated in a vacuum pan until of the right strength for rapid crystallization. To ascertain this point, the workman places a drop between his finger and thumb, and tests into what length of thread it can be drawn. If the right strength has been reached, some cold unboiled solution is added. Crystals at once appear. If the sugar is finally to be cast in loaves, the conditions are so adjusted as only to produce small crystals. The mixture of crystals and sirup is then heated to within thirty or forty degrees of the boiling point of water, and poured into the iron moulds of the familiar shape. At the apex of the mould there is an aperture which when unplugged allows the sirup to drain away. Finally, the remaining traces of sirup are removed by allowing a quantity of fine colorless sirup to percolate through the loaf. After the loaf has been subsequently dried and turned in a lathe, it is ready for the market.

Thus, then, the production of sugar is completed. The plants utilize the waste products of animal existence, and work their wonderful chemical transformations. Man gathers wealth from these storehouses of nature, and exercises his ingenuity in obtaining as much as possible. So the history of a lump of sugar contains the story of how plants work, and how mankind inherits their store by aid of labor both of mind and body.

HEALTH MATTERS.

Weight of the Body in Typhoid-Fever.

DR. L. H. COHIN has published a thesis in which he sets forth the daily variations in the weight of patients in typhoid-fever. This publication is the result of studies pursued in Cochin Hospital, where, by a skilful contrivance, successive series of patients were carefully weighed every day, and the weight recorded on their charts, from the beginning to the end of the fever.

The observations of Dr. Cohin, as given in the *Boston Medical and Surgical Journal*, show that the loss of weight varies considerably for each individual. With some it was two hundred grams a day: this was the minimum. With others it was five hundred grams: this was the maximum. The mean of nine observations gives four hundred grams of loss per day; but on taking mild cases, free from complication, the mean fell to three hundred and twenty grams, which represents the daily loss in typhoid-fever of average intensity. The mean of the daily gain, when convalescence was established, was two hundred and eighty grams. The maximum of loss of weight corresponded to the end of the second week, or the beginning of the third. In reviewing the researches on the causes of the loss of weight in typhoid patients, the writer establishes the fact that the febricitant lives at the expense of his own substance.

The conclusions of these studies are as follows: (1) Typhoid-fever presents two distinct periods, one of loss and one of gain; certain accidental causes may modify them, but cannot affect their general character. (2) The daily loss is due to febrile combustion chiefly, and but little to abstinence. (3) The daily loss varies with individuals. (4) The losses in nitrogen and in weight are almost parallel with the march of the temperature, without always following it exactly. (5) The study of the weight-chart may aid in prognosis, a continual rise in the weight being a sign of convalescence. (6) The complications of the disease augment the loss of weight. (7) The study of the loss of weight enables the physician to determine with precision the action of nutritive substances in fevers. (8) The loss of weight in a typhoid patient takes place each day in a uniform manner.

HEALTH IN THE FRENCH ARMY. — According to the official report of the French minister of war, the mortality among the French troops has fallen from twelve to eight per thousand during the last year. From 1875 to 1887 there have occurred 141,648 cases of typhoid-fever, and 21,116 deaths. The percentage of this disease has materially decreased of late, owing to the attention that is being paid to pure water-supply in the barracks. The value of vaccination is proved by the fact that the number of small-pox cases has fallen from 1,042 to 242, and these were mostly among recruits.

NEW METHOD OF PRECIPITATING SEWAGE.—The problem of the disposal of the sewage of large towns has long defied the efforts of sanitary engineers to cope with it in a satisfactory manner. A new method of sterilizing and precipitating sewage has just been brought out, which, it is claimed, accomplishes all that can be required of it at as little cost as any such system can be worked. The method has been put in practice experimentally at