

are beneficial in Australia to be less so when brought to this country; a deduction which brings out still more clearly the exceptional nature of the case of *Vedalia* and *Icerya*, just as there are some notable exceptions, as in the case of the grape phylloxera, in the introductions from America to Europe.

There are some instances in which there can be no doubt whatever as to the good which will flow from the introduction of beneficial species, and an illustration is afforded in the Caprifig insect, *Blastophaga psenes*. There can be no question as to the good which would result from the introduction of this species from Smyrna into those sections of California where the Smyrna fig is grown without its intervention, and there are other similar instances which promise well and involve no risk. But I have said enough to show that the successful utilization of beneficial insects is by no means a simple matter, and that discriminating knowledge is required to insure success or prevent disaster, especially in the second category dealt with in this paper. The danger attending introductions of beneficial species by unconsciously accompanying them with injurious forms, or by failure to appreciate the facts here set forth, is well illustrated by the introduction to Europe of our *Peronospora viticola*, of the English sparrow to America, and of the mongoose to Jamaica.

Wherever the importance of the matter leads to legislation, what are denominated "political" methods are apt either to control or in some way influence the resulting efforts—too often with unfortunate consequences. We should, as economic entomologists, be on the alert for the special cases where the introduction or dissemination of beneficial species promises good results, and do our best to encourage an intelligent public appreciation of such special cases, while discouraging all that is of unscientific or sensational nature, as likely to mislead and ultimately do our profession more harm than good.

CHANGE OF VOLUME WHEN LIQUIDS OF DIFFERENT DENSITIES ARE MIXED.*

By WILBUR S. SCOVILLE.

FROM time to time articles appear in our text books, journals, and proceedings, offering a rule whereby liquids of different densities may be mixed to obtain any desired intermediate density. These rules are necessarily limited to those liquids which neither contract nor expand when mixed, but the fact has apparently been overlooked that such liquids are rare rather than common.

It has been known for some time that solutions of salts contract when diluted, or, in other words, if an aqueous solution of a salt be diluted with water, the volume of the mixture is generally less than the sum of the volume used in producing it. The same is generally true of indifferent liquids, though in a few cases expansion occurs rather than contraction, and in some no change in volume can be observed.

At the same time that this change in volume occurs, a slight change in temperature also takes place. There is commonly an elevation of temperature, but some-



times a lowering occurs, and in many cases no change in temperature is observed. This change in temperature bears no relation to the change in volume, since contraction may be accompanied by either an elevation or lowering of temperature, or with no change in temperature, and likewise an expansion in volume may be accompanied by a change in temperature in either direction, or with none at all.

In the present paper no attempt has been made to measure the changes in temperature, the object being only to call attention to the changes in volume which occur, to show how nearly universal this change is, and to demonstrate that it is of sufficient extent to render void the use of specific gravity rules, in most cases, for anything except approximate results.

To illustrate, a mixture of glycerin and water in the proportions and quantities used in the table appended, contracts 2.0 c. c., which may be taken as a mean of the contractions. The calculated gravity of such a mixture, provided no contraction takes place, would be 1.1369 (approx.), [89 c. c. × 1.2554 = 111.73 G. + 77 = 188.73 ÷ 166 = 1.1369]. But the contraction changes the quantity to 1.1508 (approximate), (188.73 ÷ 164 = 1.15079), a difference of two in the second decimal, which is verified by trial.

The apparatus by which the contractions were measured consisted of a double bulb of glass, the lower of which bulbs was extended into a tube 15 cm. long, graduated to hold 10 c. c. in $\frac{1}{10}$ c. c.; 0.05 c. c. could be read easily in this tube. The upper bulb was fitted with an accurately ground stopper, the two bulbs connecting at opposite sides. In using it, the lower tube and bulb was completely filled with the heavier liquid at 20° C., by means of a long stem funnel, then the lighter liquid flowed into the upper

bulb, which was filled to the brim, so that insertion of the stopper displaced a part of this liquid, and no air space was left in the apparatus.

The liquids were then mixed by inverting the apparatus and shaking, placed in a water bath kept at 20° C. until this temperature was uniform in the apparatus, then the contractions read upon the graduated tube. The lower bulb and tube held 89 c. c., the upper bulb 77 c. c.

It was better for appearance sake to have used an apparatus holding equal volumes of each liquid; but as the only object was to show that there is a change of volume in most cases, and as an accurate table showing the extent of such change would be of little or no practical value, no attempt was made to construct such a table.

The common solvents and most soluble salts used in pharmacy were selected for experimentation, the salts being used in aqueous solution, nearly saturated. Gravities were all taken at 15° C.; the liquids mixed and contractions read at 20° C.

The results are given in the following table:

Heavier Liquid.	Spec. Grav.	Lighter Liquid.	Spec. Grav.	Contraction.
Acid, Acetic Glacial.	1.0615	Water	1.0000	5 c. c.
Acid, Citric	1.2620	"	1.0000	0.5 c. c.
Acid, Hydrobromic	1.2364	"	1.0000	None.
Acid, Hydrochloric	1.1754	"	1.0000	0.75 c. c.
Acid, Nitric	1.4210	"	1.0000	6.45 c. c.
Acid, Tartaric	1.3205	"	1.0000	0.8 c. c.
Alcohol	0.8199	Ether	0.7279	1.85 c. c.
Alum.	1.0515	Water	1.0000	Very slight.
Ammonia Water	0.8977	"	1.0000	None.
Ammonium Chloride	1.0765	"	1.0000	0.35 c. c.
Calcium Chlor de.	1.3070	"	1.0000	1.2 c. c.
Carbon Bisulphide	1.2711	Benzine	0.6975	None.
Carbon Bisulphide	1.2711	Cotton Seed Oil	0.9329	None.
Chloroform	1.4896	Ether	0.7279	2.1 c. c.
Chloroform	1.4896	Oil Turpentine	0.8751	Slight expansion.
Chloral	1.3615	Water	1.0000	0.6 c. c.
Copper Sulphate	1.4077	"	1.0000	0.5 c. c.
Glycerin	1.2554	"	1.0000	2.0 c. c.
Iron Sulphate	1.2405	"	1.0000	0.6 c. c.
Magnesia Sulphate	1.2862	"	1.0000	1.2 c. c.
Oil Turpentine	0.8751	Ether	0.7279	0.5 c. c.
Potass. Bicarbonate	1.1587	Water	1.0000	0.45 c. c.
Potass. Bromide	1.3557	"	1.0000	0.55 c. c.
Potass. Carbonate	1.4282	"	1.0000	2.55 c. c.
Potass. Iodide	1.6440	"	1.0000	0.55 c. c.
Potass. Nitrate	1.1377	"	1.0000	0.25 c. c.
Sodium Carbonate	1.2281	"	1.0000	1.15 c. c.
Sodium Chloride	1.2052	"	1.0000	0.7 c. c.
Sodium Salicylate	1.1945	"	1.0000	0.7 c. c.
Sodium Sulphate	1.1198	"	1.0000	0.3 c. c.
Soda (caustic)	1.4867	"	1.0000	6.6 c. c.
Syrup	1.3462	"	1.0000	0.45 c. c.
Zinc Sulphate	1.4717	"	1.0000	1.7 c. c.
Water	1.0000	Alcohol	0.8199	4.65 c. c.

THE CHEMISTRY OF BACTERIA.*

By R. WARINGTON.

THE immense variety of substances produced in the vegetable kingdom has always been a source of astonishment to the chemist. The plant is, indeed, the finest chemical laboratory with which we are acquainted. While some kinds of chemical work are common to all plants, there is hardly a species which does not possess some special capacities—which does not produce some products different from its neighbors. When we survey the whole vegetable kingdom, the extent to which this specialization is carried, and the immense variety of the products obtained, become simply overwhelming. Chemists are still unacquainted with the larger part of the substances produced by plants. When we turn from the products of plant work to the materials employed our wonder still increases, for these materials are of the simplest kind—water, carbonic acid gas, oxygen, nitric acid, and a few inorganic salts—yet out of these the whole of the immense variety of vegetable products is constructed.

This being the case, we need hardly say that the methods of plant chemistry are of supreme interest, both to the chemist and to the vegetable physiologist. By the aid of what forces, through what course of reactions, are the simple materials moulded to their final issue? The higher plants are in some respects unfavorable subjects for the study of plant chemistry. Their different parts have different functions, and the changes in progress are obscured to the student by the fact that changes of a very different type are in progress at the same time, and in places very near to each other. What would not the physiologist give if he could isolate a single cell, and grow it by itself in solutions of known composition; when by studying the nature of the cell's new growth, and the variations taking place in the nourishing solution, he might hope to be able to grasp the facts of cell nutrition and the nature of its waste products? Such an opportunity is actually afforded when we study the chemical changes brought about by bacteria.

In bacteria we have the vegetable cell in its simplest form; we have a mass of protoplasm and a cell wall, but the cell is single or united with a few others, and, as far as we know, the life changes in all the cells of every species living under the same conditions are the same. Moreover, these organisms grow freely in suitable solutions, and the chemical changes produced in the materials held in these solutions can be readily ascertained. We have thus in a study of the chemistry of bacteria a splendid opportunity for enlarging our knowledge of plant chemistry, and, indeed, of becoming acquainted with the fundamental reactions on which synthetical organic chemistry depends.

The study of the chemical work performed by bacteria has occupied as yet but a few years, but the results have been most remarkable. The immensely numerous species of bacteria have been found to exhibit an almost equally great diversity of action. Different members of the class have been found to flourish under entirely opposite conditions, to feed on wholly different materials, to perform an immense variety of chemical work upon the media in which they live, and yet the chief product of plant life—the formation of protoplasm and cell wall—is probably in each case practically the same. The study of the chemistry of bacteria has thus greatly enlarged our conceptions of the chemical power of the vegetable cell.

As a contribution to the discussion to-day, I propose to call attention to the chemical actions displayed by three species of bacteria existing in the soil, and

all of first-class importance in their relations to agriculture.

It is well known that all ordinary soils contain organisms possessing a vigorous power of oxidizing—of bringing about a combination between the oxygen of the air and various organic and inorganic bodies. Thus dead vegetable and animal tissues in soil are, under favorable conditions of heat and moisture, resolved into carbonic acid, water and nitric acid.

Particular experiments show that the nitrogen of albumin, gelatin, asparagin, urea, ammonia, ethylamine, and thiocyanates is converted by soil into nitric acid. Nor is the action confined to organic matter; for nitrites are oxidized to nitrates, iodides to hypoiodites and iodates, and bromides to hypobromites and bromates.

The organisms producing nitric acid have been made the subject of study by many chemists, and after much labor and many disappointments they have been satisfactorily isolated.

We now know that the production of nitrates in the soil—a process of the greatest importance for the nutrition of agricultural crops—is accomplished by the action of two organisms, each of which performs a distinct stage in the work. By one organism ammonium carbonate is oxidized and the nitrogen converted into a nitrite. By the second organism nitrites are converted into nitrates. We have here an excellent example of the way in which certain special functions, certain narrowly limited lines of work, are exercised by individual species of bacteria. The nitrous organism can oxidize ammonia to nitrite, but it cannot change a nitrite into a nitrate. The nitric organism, on the other hand, oxidizes nitrites readily, but it cannot oxidize ammonia. Both organisms are present in all fertile soils, but the formation of nitrites is not usually perceived, as they are at once converted into nitrates.

The organisms we have mentioned grow and exercise their functions in dilute solutions of appropriate composition, and it is therefore possible to study exactly the mode of their nutrition.

Like every other living organism, they develop and perform their functions only when certain inorganic salts supplying phosphates, sulphates, potassium, calcium, and magnesium are present. The continued omission of one of these has been proved in several cases to bring about a cessation both of growth and function. The general fact is familiar to physiologists, but it is singular that we have as yet no rational idea of the mode in which these various inorganic bodies assist in plant nutrition, with the exception of the fact that sulphur, and possibly in some cases phosphorus, are constituents of albuminoid bodies.

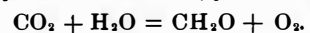
As to nitrogenous food, these organisms are amply furnished by the ammonia, the nitrite, or nitrate which is intentionally added to the solution; the addition of no other nitrogenous substance is necessary. Here, too, we are on familiar ground. Ammonia and nitrates are both well known as the most appropriate nitrogenous food for plants.

When we inquire, however, what is the source of carbon to the nitrifying organisms, we are confronted by a startling novelty. It is found to be quite unnecessary to supply these organisms with any carbonaceous food save carbonates, bicarbonates being preferred. The fact of the conversion of carbonates into organic cell substance has been conclusively proved in the case of the nitrous organism; it is at present assumed to be also true of the nitric organism, as this also requires the addition of no organic carbon to its nutritive solution.

The fact that green plants exposed to sunlight are capable of forming organic substances from the carbonic acid and water of the atmosphere is well known to physiologists, but it is equally certain that this action does not occur in the dark. Yet here we have a colorless cell, destitute of chlorophyll, growing in the dark, which, nevertheless, is capable of decomposing carbonic acid, and producing from it carbonaceous cell substance. From a purely chemical point of view this reaction may well appear at first sight incredible, as the decomposition of carbonic acid is an action requiring the consumption of much energy, which in the case of the green plant is supplied by the sun's rays, but in the case of the nitrifying organism is supplied in no such way.

This theoretical difficulty disappears, however, when we look at the whole reaction brought about by the nitrous organism. This organism attacks carbonic acid in its combination as ammonium carbonate, and the formation of an organic carbon compound proceeds at the same time as the oxidation of the ammonia; the result of the whole reaction being the liberation of heat, and not its consumption. A supply of external energy is thus not required.

Expressed in its simplest terms, the green plant manufactures carbohydrates from carbonic acid and water by a consumption of solar energy as follows:



The nitrous bacterium oxidizes ammonium carbonate, producing at the same time ammonium nitrite and a carbohydrate; this reaction we may express in its simplest form as follows:



The equation, however, by no means fully expresses what actually occurs, as Winogradsky finds that 35 parts of nitrogen as ammonia are oxidized for one part of carbon assimilated; the whole reaction is thus strongly exothermic.

The nitric organism multiplies more slowly than the nitrous, and does not therefore afford so good a subject for quantitative experiments; its nutrition has not yet been fully studied.

The last organism I wish to speak of is the one of which Winogradsky has given a preliminary description during the past summer. It has been obtained from soil, and possesses the remarkable power of assimilating the free nitrogen of the atmosphere. To accomplish this assimilation it is simply necessary to grow it in a solution containing sugar (dextrose) and the necessary salts, no combined hydrogen being supplied. Under these circumstances a vigorous growth of the bacillus takes place, the sugar undergoes a butyric fermentation, and at the end of the operation it is found that the culture has acquired nitrogen, the amount being apparently about one five-hundredth of

*Read at the forty-first annual meeting of the A. P. A.—Western Druggist.

*A paper read before a conference of Sections B and D, Nottingham meeting, 1893.—Chem. News.