absorbed by the roots pass up to the leaves, where they are concerned in the constructive metabolism going on in those organs. The products of these processes pass from the leaves to parts of the plant which are actively growing, and where plastic material is required, or to the seeds or other organs in which organic stores are being laid up.

If the stems or plants are cut in the spring, a flow of sap proceeds from the cut surface of that portion of the stem which is connected with the roots. This fact was investigated by Hales.¹ He concluded that there is "a considerable energy in the root to push up sap in the bleeding season." This force is termed the root pressure, and is the measure of the absorbent activity of the root hairs. The root pressure is not only manifested by causing the flow of sap. It also may cause the exudation of drops of sap on the surface. There is a marked periodicity in the flow of sap, which is not due to the immediate result of variations in external conditions, but is inherent in the absorbent cells themselves.

The current travels from the roots to the leaves through the lignified cell walls of the wood of the plant. The activity of the exhalation of watery vapor from the plant is not the same from their surfaces. The refreshing effect of a shower on withered leaves is due to the moisture penetrating the soil and being absorbed by the root hairs. From experiments² it has been shown that if the air is very moist and the leaves dry, the leaf surfaces may absorb a little water.

The cuticle offers a certain amount of resistance to the passage through it of vapor which is due to resinous or waxy substances contained in it. The Mexican *Cotilla*³ offers a striking example. It grows in very dry and exposed parts of the country, where rainfalls are infrequent. The bark is chiefly composed of wax and resinous substances.

Other substances, as well as water, can be absorbed by leaves,⁴ experiments having shown that if a drop of calcium sulphate solution be placed on a leaf, it will have disappeared in the course of a few hours. This is more rapid when placed on the under surface. Though it seems that leaves may absorb water and substances in solution under certain circumstances, the especial absorptive function of leaves is the absorption of gases, as has been already explained.

The subject of the ash constituents of plants is a very important one in this connection. The essential mineral constituents of plants have already been mentioned. Silicon, fluorine, manganese, sodium, lithium, rubidium, cesium, barium, aluminum, zinc, copper, titanium, iodine, and bromine have also been found among the ash ingredients of certain plants.

The method of absorption of soluble mineral salts has already been described. A solution of insoluble salts is brought about in a different way. A soil rich in organic matter is always charged with carbon dioxide, and this gas is also given off by the roots of living plants. Water containing this gas is able to dissolve calcium carbonate and some silicates which are insoluble in pure water. The presence of certain soluble salts in the soil brings about a decomposition and renders the insoluble salts more readily soluble. Finally, the insoluble salts are brought into solution by means of the acid sap which saturates the cell wall of the root hair. This acid is not carbonic acid, for its reddening of litmus paper is permanent.

It has been shown by experiment that the chemical elements are not universally absorbed by roots in their combinations in the soil.

The wide differences in the composition of the ashes of plants show that each plant is endowed with a specific absorbent capacity. It is upon this fact that the "rotation of crops" in farming depends. A graminaceous plant⁵ is able to withdraw relatively larger quantities of silica from the soil than a leguminous plant. The latter can only do so to a very slight extent.

The absorbent capacities of nearly allied species are very different. Again, individuals of the same species yield different ash compositions, depending upon their vigor; and the absorbent capacity of the plant varies at different periods of its life. It has been stated that "similar kinds of plants, and especially the same parts of similar plants, exhibit a close general agreement in the composition of their ashes, while plants which are unlike in their botanical characters are also unlike in the proportions of their fixed ingredients."⁶ If an ash constituent can pass through a cell wall, its absorption will take place independently of its use or harmfulness to the plant, but the absorption of essential inorganic constituents will depend upon its relation to the metabolism of the plant.

The ash constituents of a plant increase from the roots upward to the leaves, a fact showing that the leaves are the organs in which more especially active chemical changes take place.

The ash ingredients are usually present in each plant cell; in the cell wall, embedded in the cellulose, and partly in the contents of the cell. The salts of the alkaline metals and of the sulphates and the chlorides of magnesium and calcium occur in the solution of the sap. Silica and phosphates of calcium and magnesium are mostly insoluble, and exist in the tissues of the plant.

Water culture experiments⁷ have shown the essential ash ingredients, like phosphorus, is always found in relation with living protoplasm. If⁸ the plant was not supplied with potassium, it grew very little, and very little starch was formed in the chlorophyll corpuscles of the leaves. On the addition of potassium chloride, the starch grains became more numerous in the leaves, and made their appearance in other parts of the plants. Potassium, doubtless, plays an important role in the formation and the storing up of carbohydrates, for the organs in which these processes are active, as the leaves, seeds, and tubers, are found to be the richest in this element.

It has been observed that cesium⁹ and rubidium can

replace potassium in the food of certain fungi (mould, yeast, and bacteria).

Salm-Horstmar describes¹ some experiments, from which he infers that minute traces of lithium and fluorine are indispensable to the fruiting of barley. The same investigator has concluded that a trace of titanate acid is a necessary ingredient of plants.

Zinc² is also a frequent constituent of plants growing about zinc mines. Certain marked varieties of plants are peculiar to, and appear to have been developed by, such soils, as the violet, var. *calaminarias*, and pennycress. In the leaves of the latter plants thirteen per cent. of zinc oxide was found; in other plants from 0.3 per cent. to 3.3 per cent.

From the investigations of Baumann,³ insoluble zinc salts in the soil are harmless to plants. All plants excepting the coniferæ speedily die in a solution containing 10 mg. zinc to the liter, though traces of zinc in solution are harmless.

The specific action of zinc on the vegetable organism consists in a destruction of the chlorophyll coloring matter and a consequent stoppage of the whole process of assimilation.

Experiments⁴ on maize, oats, buckwheat, show that arsenic attacks the protoplasm of the cell and destroys the power of osmose by the roots.

Sulphates occur in the cell sap of organs where chemical changes are rapidly taking place, and are doubtless formed in connection with the decomposition of proteids. Phosphorus occurs in actively growing cells in the most various plants. It has been found present in the green coloring matter of the leaves, and is always found in relation with living protoplasm. Schumacher⁵ holds that the chief work of the alkaline phosphates is the acceleration of the diffusion of these difficultly diffusible albuminoids.

Calcium is especially abundant in the leaves of green trees, and it cannot be replaced in the food of green leaves by any other metal. It can be replaced by strontium,⁶ barium, or magnesium in the food of certain fungi. Magnesium⁷ resembles lime in many points, but is present in larger quantity in the stem and grain, and not in the leaves of the maize plant.

Iron is found to be essential to green plants only. If a seedling be cultivated by water culture in a fluid containing no iron, the leaves will become pale until at length they are nearly white; but on the addition of a small quantity of iron to the solution, or if the white leaves are painted with a dilute iron solution, they will very shortly become green. It plays an important part in the formation of the green coloring matter, though it does not enter into its chemical composition.

"Buckwheat,⁸ barley, and oats do not flourish when grown in solutions containing no chlorides, and as in these plants the chlorophyll corpuscles become overfilled with starch grains, it was thought that this element was of importance in connection with the translocation of carbohydrates."

Sodium⁹ has been used in water culture to replace potassium, but the plants deprived of potash did not develop.

Manganese is abundant in the ash of *Trapa natans*. I also found it in the different portions of *Yucca angustifolia*.¹⁰

Iodine and bromine are found in marine *Algae* and in minute quantity in some plants grown far from the sea.

Silica is found in the form of soluble or insoluble silicic acid. It occurs principally in the cell wall, but it has been found in the cell sap of a plant (*Equisetum hiemale*),¹¹ and certain cells in the pseudo bulbs of epiphytic orchids¹² contain each a plate of silica.

Experiments have shown that the absorption of silicic¹³ acid greatly assists the assimilation of other plant foods, and that plants to which it is supplied show a decidedly more healthy development of grain and straw than others not so treated. Silica is doubtless of mechanical use, giving firmness and rigidity to plant tissues; though the real cause of "laying" of crops has been found to be due to the imperfect development of the tissue, and not to an insufficient supply of silica.

The percentage of ash constituents in plants varies, but the quantity is sufficient to be a very important factor in the consideration of chemical forms of plants.

I have already said that the albuminous cell contents, called protoplasm, are always present in the living cells of plants. The introduction into the cell of the gases, water, and inorganic substances goes to the direct formation of this colloidal body, or assists in it.

It has been stated that the soil, water, and atmosphere supply the food of all plants. It would be of interest to dwell upon the processes of assimilation, and the chemical changes that go on within the living plant, if our time would allow. It may be mentioned that nowhere in any department of chemistry have our former views been more modified than in the physiological chemistry of the vegetable cell during the last three years.

For example, I may say that at least in some plants nascent starch passes in a soluble form from cell to cell by osmosis without conversion into sugar, as was formerly held.

Sugar in some plants may be regarded as a waste product, resulting from the breaking down of more complex substances, of no further service in the development of the plant.

Sorghum¹⁴ cane, at the time of the maturing of the seed and the full growth of the plant, contains the largest percentage of sugar, and this sugar appears to be really a waste product.

The classification¹ of *Plastic and Waste Products*, in Vines' late *Physiology*, cannot be accepted as final, since many changes in plant chemistry have resulted since 1882—the date of his chemical bibliography.

It may be generally said that the proteids or albuminoid substances are formed in the cell from a simple carbohydrate and some nitrogenous body, probably an amide.

The inorganic acids supply sulphur and other substances necessary to enter into combination with the proteid, or act mechanically by removing waste material.

The function of chlorophyll may be briefly stated.² It absorbs certain rays of light, and thus enables the protoplasm of the cell to avail itself of the radiant energy of the sun's rays for the construction of organic substances from carbon dioxide and water.

Plants which are grown in the dark, or at low temperature, are usually of a yellow color. Such plants are said to be etiolated. There is reason to think that this yellow substance, etiolin, is an intermediate substance in the formation of chlorophyll, for if it is exposed to light it is converted into a green color. These complex coloring matters are probably derivatives of protoplasm.

The autumnal change of leaves is owing to a third coloring matter, called xanthophyll. In many cases, the leaves also contain a red coloring matter, erythrophyll.

The importance of chlorophyll in the plant will be admitted when it is said that the absorption of carbon dioxide, the evolution of oxygen, and the formation of many organic substances are effected solely by chlorophyll corpuscles.

The organic acids occur in plants free and also in combination with bases. It is to the presence of these bodies that the acid reaction of plant tissues is due. Some organic acids are assimilated by plants; the turgidity of cells is to be ascribed to their presence, and the acid sap in root hairs renders possible the solution and absorption of mineral substances insoluble in water.

The primary function of the resins³ of coniferæ and analogous juices of other plants is to render service in cases of injury, and, by covering the wound with a protecting coating, to favor its healing.

During my studies on the *Yucca*,⁴ resins and saponin were separated from each part of the plant. Experiments were made to determine the emulsive power of saponin on resins. It was found that aqueous solutions of saponin were able to emulsify many classes of resins, and in my paper it was pointed out that saponin may serve mechanical purposes in the plant as well as those of nutrition.

(To be continued.)

ANALYSIS OF CIDER OR APPLE VINEGAR.

By B. F. DAVENPORT.

THE following detailed practical method of determining whether a sample of "cider vinegar or apple vinegar" conforms to the requirements of the Massachusetts statute relating thereto, which requires that it should be not only the legitimate and exclusive product of pure apple juice or cider, but also that it should not fall below the quality of possessing an acidity equivalent to the presence of not less than 4½ per cent. by weight of absolute, that is monohydrated, acetic acid, and should yield upon full evaporation at the temperature of boiling water not less than 2 per cent. by weight of cider vinegar solids, may prove of interest to those dealing in the article.

As the limits set by the statute are in per cents. by weight, the portion of vinegar taken for the tests should, for perfect accuracy, be also taken by weight. That is, the quantities of 6 and of 10 grammes are to be taken for the tests of strength and of residue; but as taking it by measure, if of about the ordinary atmospheric temperature of 60° to 70° F., will make the apparent percentage at most only 1 to 2 per cent. of itself greater than the true, that is, will make a true 5 per cent. vinegar appear to be, say, from 5.05 to 5.10 per cent., measuring proves in practice to be accurate enough for all common commercial purposes, and therefore the quantities of 6 and of 10 cubic centimeters by measure may be taken in place of as many grammes.

It is most convenient to have the measuring burette of a size to contain 25 to 50 c. c., that is cubic centimeters, and have these divided into tenths. The best form of burette is the Mohr's, which is closed by a glass stop-cock. Besides this only a dropping tube, called a pipette, graduated to deliver 6 and 10 c. c., will be needed.

The only two chemicals needed in determining the strength of a vinegar are a 1 per cent. solution of phenolphthalein in diluted alcohol and a sufficient quantity of the volumetric solution of soda.

Having these, the procedure for making the test will be as follows: Fill the pipette by suction and then quickly close the top of it with the forefinger. Raise the tube out of the sample of vinegar and let it empty out by drops exactly down to the top graduation mark, this bearing the mark of 0 c. c. Then holding it over a white mug or cup, let it run out exactly down to the 6 c. c. mark. Dilute the 6 c. c. of vinegar, thus measured out into the mug, with sufficient clean water to make it look about white, and then add to it about three drops of the phenolphthalein solution.

Then having prepared the burette by filling it up to the top, zero, or any other noted mark of the graduation, with the volumetric solution of soda, let the soda solution run out cautiously into the diluted vinegar, which should be constantly stirred about. As soon as the vinegar in the mug begins to darken, the soda should then only be allowed to run into it by drops. This dropping is thus continued until at last a final drop of soda turns the vinegar suddenly to a permanent pink or cherry color, which will not disappear upon further stirring. By now reading off from the graduations of the burette the number of full c. c. divisions and of tenths which have been emptied out to bring about this change of color in the vinegar, is known the

¹ Cambridge edition. 1886.

² Cambridge edition, p. 157.

³ H. De Vries: *Chem. Centr. Bl.*, 3, xiii, 565. (*Jour. Chem. Soc.*, 1883, p. 365.)

⁴ *Trans. Am. Phil. Soc.*, Dec., 1885.

¹ *Jour. fur Prakt. Chem.*, 1884, p. 140.

² A. Braun and Risse (Sachs: *Exp. Physiologie*, 153).

³ Landw. Versuchs-Stat., xxxi, 1-53 (*Jour. Chem. Soc.*, 1884, p. 1408).

⁴ F. Nobbe and others. Landw. Versuchs-Stat., xxx, 331-422. (*Jour. Chem. Soc.*, 1884, p. 1409).

⁵ *Physik der Pflanze*, p. 128.

⁶ Naegeli.

⁷ R. Hornberger and E. V. Raumer; *Bied. Centr. Bl.*, 1882, 837-844 (*Jour. Chem. Soc.*, 1883, p. 491).

⁸ Vines. Cambridge edition, p. 136. Also, Beyer: *Landw. Versuchs-Stat.*, xi. Leydhecker: *ibid.*, viii.

⁹ Salm-Horstmar; Knop and Schreber.

¹⁰ *Yucca angustifolia*. Helen C. De S. Abbott, *Trans. Am. Philos. Soc.*, Dec. 18, 1885.

¹¹ Lange: *Ber. d. deutsch. chem. Ges.*, xi.

¹² Pfützer: *Flora*, 1877.

¹³ C. Krenzhage and E. Wolf: *Landw. Versuchs-Stat.*, xxx, 161-198. (*Jour. Chem. Soc.*, 1884, p. 1112.)

¹⁴ H. W. Wiley. *Botanical Gazette*, 1887.

¹ *Statistical Essays*, 1, 1769 (4th edition).

² Detmer and Boussingault.

³ H. C. De S. Abbott, *Proc. A. A. S.*, xxxiii (Am. Journal Pharm., Feb., 1885).

⁴ Boussingault: *Ann. Chem. et Phys.*, ser. V, xiii; also, *Agronomie*, VI, 1878. Mayer: *Landwirthschaftl. Versuchs-Stat.*, xvii, 1874.

⁵ Wolff: *Aschen Analysen*, 1871.

⁶ How Crops Grow. By S. W. Johnson. London, p. 145.

⁷ Nobbe, Siegert, Wolff, Stohmann, Sachs, and others.

⁸ Nobbe: *Die organische Leistung des Kaliums*, 1871.

⁹ Naegeli: *Sitzber. d. Akad. d. Wiss. zu Munchen*, 1880.

per cents. and tenths of acidity equivalent to true acetic acid contained in the vinegar being examined. This, if it is a pure cider vinegar and well made, will be upon the average about 6 per cent., but never under 5 per cent. If in like manner 10 c. c. of the vinegar is exactly measured off by the pipette into a small light porcelain dish, and then evaporated fully to dryness over boiling water, the number of grammes weight gained by the dish, when multiplied by ten, gives the percentage of solid residue contained in the vinegar.

There are certain characteristics peculiar to the residue of a pure cider vinegar, the principal of which are the following: It will be about 3 per cent. in weight, and never less than 2 per cent. It is always soft, viscid, of apple flavor, somewhat acid and astringent in taste. A drop of it taken up in a clean loop of platinum or of iron wire and ignited in a colorless Bunsen gas lamp flame imparts to it the pale lilac color of a pure potash salt, without any yellow due to sodium being visible. The ignited residue left in the loop of wire will be a fusible bead of quite a good size, and it will leave a strong alkaline reaction upon moistened test paper, effervescing briskly when immersed in an acid. The presence in a vinegar of the slightest trace of any free mineral acid will prevent the ignited residue leaving any alkaline reaction, or effervescing with acids. The presence of any practical amount of commercial acetic acid added to "tone up" the strength of the vinegar will cause the igniting residue to impart another color to the Bunsen flame, and the residue itself will have a smoky pyroigneous taste or odor. Any corn glucose used in the vinegar will cause its residue when ignited to emit the characteristic odor of burning corn, and as the last spark glows through the carbonized mass to usually emit the familiar garlic odor of arsenic, for the common oil of vitriol usually used in the production of glucose is now mostly derived from pyrites, which almost always contain arsenic.

A glucose vinegar which has been made without vaporizing the alcohol after the fermentation of the glucose will also have a strong reducing action upon a copper salt in an alkaline solution, and also will give a heavy precipitation of lime with ammonium oxalate. A true malt vinegar always contains phosphates, and a wine vinegar cream of tartar. The presence of any acid vegetable substance in a vinegar is known by the residue having a pungent taste, especially if before the evaporation the vinegar has been exactly neutralized with soda.

In a pure apple cider vinegar hydrogen sulphide gas will not cause any discoloration, nor will the addition of a solution of either barium nitrate, silver nitrate, or ammonium oxalate cause anything more than the very slightest perceptible turbidity. But the addition of some solution of lead acetate—that is, of sugar of lead—will cause an immediate voluminous and flocculent precipitation, which will all settle out in about ten minutes, leaving a clear fluid above. In most of the so called "apple vinegars" brought into this market from other States the addition of some of this lead solution will cause but a slight turbidity, without any precipitate settling out for several hours, and even then the precipitate will not be of the same appearance as in apple cider vinegar. —*Chem. News.*

MANUFACTURE OF STARCH, DEXTROSE, AND GLUCOSE.

By Prof. L. V. WAGNER.

LEON CUISINIER, in Paris, has patented a process for the saccharification of starchy substances by means of a malt which has been allowed to germinate for from 7 to 10 days. The raw materials must be made perfectly neutral (acid free) by treatment with a one per cent. soda or $\frac{1}{2}$ per cent. sulphuric acid solution, as the case may be. The grain after two or three days' soaking in tepid water should contain not more than 40-45 per cent. water, and is then to be ground. The moist materials are made into a paste with an equal weight of water, and from 2½ to five per cent. of malt is well kneaded into it, during an hour. The liquefaction of this paste takes place in an upright cylinder, surrounded by a water bath which is maintained at 75° C., and provided with powerful stirring gear. The mash thus obtained is then heated in a steam jacket, under a pressure of one atmosphere for about an hour, then cooled to 70° and treated with one to two per cent. of malt infusion. After two hours the solution is put through a filter press, cooled to 50°, and treated with fifteen to twenty per cent. of malt infusion, which is added in five per cent. lots every two hours. When thoroughly saccharified, the solution is heated again, filtered, and evaporated to 40° Be., and sold as concentrated beer wort.

Joseph Franklin Gent, of Columbus, Ind., U. S. A., frees maize from the germs and husks by steaming at 160° in a special apparatus, for not longer than one minute, and subsequently crushing and sifting the grain. The product thus obtained is then again steamed, pressed into thin cakes, and brought into the market under the name of "Cerealine."

Messrs. Vierneisel, K. Trobach, and Alfred Cards recommend the following treatment of potatoes for the purpose of dextrose manufacture, avoiding thereby the necessity for the separation of the starch from the pulp, which always retains a considerable percentage, and utilizing the roots at the period when they contain most starch—viz., at their harvest time; thus avoiding also the loss of starch which stored potatoes always undergo. The potatoes are washed and ground, the paste put through a filter press, in which the cakes are well washed with a solution of calcium bisulphite, to prevent any fermentation, and then either dried for storing or worked up forthwith. The cakes made into a suitable paste with water are saccharified under pressure, by acid. The acid sugar solution is thereupon neutralized with calcic sulphite and chalk, put through a filter press, evaporated to 30° B., again filter-pressed, and finally concentrated at 100° down to 35° B., for crystallization. The resulting sugar when separated from the molasses is ready for the usual processes of recrystallization.

Thadeus v. Korvins-Sakovicz and David Rosenblum, of Warsaw, produce crystallized grape sugar from all sorts of starch by boiling ten per cent. solutions of starch with certain quantities of sulphuric anhydride, which quantities vary from 4.9 per cent. with eleven hours' boiling when working in open vessels to 0.15 per cent. when the operation is conducted in a closed vessel and

under a pressure of four atmospheres. The boiling in the first case lasts eleven hours, in the latter only four hours. Instead of using charcoal to decolorize the neutral sugar solution, it is cooled to 45° and about 0.2 per cent. (on the weight of starch) of permanganate of potash added, whereby a brown precipitate is formed, the solution after passing through the filter press being perfectly colorless. The crystallization is performed under vacuum, but the crystals cannot be readily freed from the mother liquor.

Alf. Seyberlich, of Riga, and Alex. Trampedach, of Mitau, transform starch into sugar by the action of dilute nitric acid. The starch is made into a milk with water, and run into a dilute boiling solution of nitric acid, and boiled until ten drops of the solution added to 200 c. c. 96 per cent. alcohol no longer produce any turbidity. The proportions used are 1,000 starch, five nitric acid, and 2,000 to 3,000 water. They then recommend that the solution be made distinctly alkaline by the addition of sodium or potassium carbonate, thereupon evaporated in the vacuum apparatus to 35-36° Be., and allowed to crystallize. The crystals thus obtained are well developed, and easily separated from the mother liquor. —*Dingl. Polyt. J.*

CURIOUS PROPERTY OF GAS RETORT CARBON.

A CURIOUS property of the carbon of gas retorts has been brought under the notice of the Academie des Sciences by MM. Debray and Pechard. They observe that when pieces of retort carbon, previously purified by the action of a current of chlorine at a high temperature, are used as electrodes for the decomposition by current of acid solutions, the positive electrode disintegrates more or less quickly, forming a very finely divided black powder. This is a fact well known to experimentalists, but hitherto not explained. Most of those who have noticed the phenomenon, however, have had their attention fixed upon the alterations occurring in the fluids in which the electrodes are immersed than upon these latter.

MM. Debray and Pechard, however, are disposed to think that the disintegration of the carbon is not due to any mechanical action, but to an alteration, more or less profound, of the matter itself, and that the powdery matter produced by the carbon is, in reality, of the nature of an alloy of carbon. It has been found

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that this pulverulent carbon contains oxygen, water, and even nitrogen, when it has been used in the electrolysis of nitric acid. These various matters were, therefore, united with the carbon under the influence of the electric current. Whatever the electrolytic acid used, this black powder, well washed and dried *in vacuo*, deflagrates when heated in a glass tube just below a red heat. The deflagrated carbon disengages also, under a more lively heat, carbonic oxide and carbonic acid. It is thus evident that carbon in the purest form attainable in commerce—that of retort carbon—is capable of entering directly, under the influence of an electric current, into unsuspected combinations with other elements.

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