species of the western part of California, extending eastward to the Sierra Nevada, of very variable foliage, but comparatively broad-leaved. Indeed the rounded lower leaves are sometimes barely 3-lobed, and the divisions commonly round-obovate or cuneiform. The typical form (the plant raised in the St. Petersburgh garden, from seeds gathered at the Ross Colony—of which an original has been obligingly sent me for identification) has flowers as large as those of *D. Menziesii*. Other specimens agree with this; but not rarely, both in the northern and southern districts, it is much smaller-flowered, and passes freely into

Var. **patens**, the *D. patens* Benth. Pl. Hartw. This is a common form, with narrow leaf-lobes, and a narrower raceme of rather small flowers, the pedicels in fruit ascending. It would be taken for a quite distinct species, except for the intermediate forms.

D. pauciflorum Nutt. The type of this species occurs in the Rocky Mountains, from Wyoming and adjacent parts of Colorado to Idaho, and a slender form reaches the eastern borders of Washington Territory, and also California, where

Var. **depauperatum**, taken to be *D. depauperatum* Nutt. in Torr. & Gray, having broader leaf-lobes, may really be only an attenuate form of *D. decorum* var. *patens*. Additional materials and well formed fruit are wanted.

D. Nuttallii. So named because in our herbarium it is "D. simplex" of Nuttall. It is a moderately tall species, with grumose root, apparently quite distinct in character, occurring in low grounds along and near the Columbia River, above the Dalles, where it has been of late abundantly collected by Howell, Henderson, Suksdorf, etc. Nuttall's specimen is ticketed "Columbia Plains."

On the causes of the variations in the contents of sucrose in Sorghum saccharatum.

HARVEY W. WILEY.

For some years I have been investigating the Sorghum saccharatum in respect of its adaptability to the production of sugar.

During this time many difficulties have been encountered and these troubles have all been overcome with one exception. The chief obstacles to successful sugar making have been, *first*, unfavorable climatic conditions; *second*, imperfect methods of extracting the sugar; *third*, improper treatment of the extracted juice; *fourth*, variations and rapid changes in the sucrose of the juice. All of these problems have been successfully solved save the last. It is proper to say, however, that certain methods of cultivation and certain methods of selecting seeds tend to produce maximum contents of sucrose in the cane and these methods are not yet fully developed. A proper conception of the variations to which the sucrose in sorghum is obnoxious can not be had unless we study briefly the method of its formation, how it is stored and the physiological functions in which it takes part.

Vegetable physiologists have taught us that a carbohydrate can be formed by a certain retrogressive change in protoplasm, by which the cell envelope, in other words cellulose, is produced. The carbohydrates which appear in the embryo of a plant are developed at the expense of the stores of material in the seed. After the appearance of the chlorophyll cells in the plant the production of carbohydrates takes place with their aid, CO_2 being absorbed from the air and free oxygen being eliminated.

It would be easy to explain the production of carbohydrates by supposing that the chlorophyll cell exerted a reducing influence[1] on the CO_2 which, with the assimilation of water, produced, for instance, starch by the formula $6CO_2+5H_2O=C_6H_{10}O_5+O_{12}$. In the vast majority of plants it is found, in corroboration of this supposition, that the volume of the oxygen set free is sensibly the same as the carbonic dioxide absorbed. The carbohydrate which is generally formed in the chlorophyll cells is starch. This starch is removed from the leaf, and it is supposed that the carbohydrates which are formed in all parts of the plant are derived from this original substance.

In point of fact, however, the production of organic matter in a plant does not probably take place in the simple manner above described. It is more likely that the presence of a nitrogenous body is necessary and this proteid itself is the active principle of the production of new organic matter, by a certain decomposition it suffers, with the help of carbonic dioxide and water. Nor is it by any means certain that

[1]It has lately been stated that this reduction is due to the action of electricity on the leaf—producing hydrogen—and this hydrogen is the active principle in the reduction of the carbonic dioxide. This statement appears to be purely theoretical.

starch is the only organic matter formed by the chlorophyll cells; in fact, it is known that oil is often the product of this constructive and destructive metabolism.

But it seems reasonable to suppose that the different sugars are as likely to be formed in the leaf of the plant as starch.[2] When we remember how easily starch is detected in most minute quantities and how easily sugar is missed even when present in much larger quantities, we do not wonder that vegetable physiologists have supposed that starch is the first carbohydrate formed in the leaf and that all the others are derived therefrom. The explanation which is made of the translation of the starch from the point of its formation to the localities where it is stored is as follows:

Take, for instance, the formation of starch in the germ of cereals. We are taught that the starch first formed in the leaves is changed into sugar and in this soluble state carried through the plant until it reaches the seed. This sugar, reaching the point where the seed is forming, is changed to starch again by the amyloplast.

Let us subject this theory of the translation of starch to a brief examination. There are two only known methods by which starch can be converted into sugar, *viz.: first*, by the action of certain acids, and *second*, by the action of certain ferments. The conversion of starch into sugar by acids even at a high temperature and with the stronger acids is very slow. It is simply incredible that such a conversion can take place at the ordinary temperature in the leaf of a plant and by reason of the action of the extremely dilute weak vegetable acids which the leaf contains. In the same way it must be conceded that the opportunity for the action of a ferment in the leaf is extremely limited.[3] Such action requires time and much more favorable conditions than can be found in the living leaf. In any case if sugar be formed from starch in either of the ways indicated it could not be sucrose.

In fact the reducing sugar which is found in plants is seldom starch sugar, *i. e.* maltose or dextrose. This appears to be a fact which the vegetable physiologists have entirely ignored. The sugars of plants which reduce an alkaline copper solution are either derived from sucrose by inversion

[2]Meyer (*Botanische Zeitung*, 44, Nos. 5, 6, 7, 8) has lately shown that the leaf of the plant is incapable of forming starch out of sucrose, lævulose, etc., and calls especial attention to the fact that starch may not be the original substance formed.

[3]The ferment which acts on the starch has been studied by Brasse and Schimper (Bied. *Centralblatt*, vol. 14, p. 169, vol. 15, pp. 310 and 473). It is called *amylase*.

or more probably are of independent formation. If they were derived from starch they would show dextro- if from sucrose, lævo-gyration. In point of fact they often show neither, as I long ago pointed out when in view of this optical inactivity I proposed for them the name of anoptose. When they do show rotation, however, it is left-handed.

It seems to me that there is one fact that the physiologists forget, *viz.*, that starch is not always insoluble. In my examinations of sorghum juices I have never failed to find soluble starch when I looked for it. The existence of bodies when first formed in the soluble state, which when once made solid become insoluble, is not unknown. Certain forms of silica are illustrations of this. It seems much more reasonable to suppose that in the case of the sorghum for instance the starch which appears in the seed is partly transferred directly from the soluble nascent state to the seat of its final deposition. This, indeed, is hardly a theory in the light of the fact mentioned above: that the sap of the plant always contains soluble starch.

Led by the commonly accepted theory that the starch in the grain of cereals, etc., was formed from sugar, a few years ago some experiments were made to increase the sucrose in sorghum by cutting away the seed heads as they appeared and thus preventing the formation of starch. Two or three analyses were made and the results showed a large increase in the sucrose in those plants in which the formation of starch had been prevented.

In 1885 I conducted some experiments on a large scale. About two acres of a sorghum field were selected. In each alternate row of the growing cane the seed heads were removed as they appeared. Numerous analyses were made of the canes from both kinds of rows. The result showed most conclusively that no marked increase of sucrose was noticed by reason of the prevention of the deposition of starch. It is far more simple to suppose that the sucrose which we find in sorghum is produced directly by the decomposition of protoplasm in presence of carbonic acid, provoked by the katalytic action of the chlorophyll cell. At any rate there is no sort of evidence that it is ever made from starch and no physiologist has ever invented any hypothetical saccharoplast to account for such a transformation.

This subject of the origin of sucrose is of great interest but I have not yet finished my experimental studies of it and so will not pursue it further at present.

The question now arises is the sucrose of sorghum a plastic material, reserve material, or waste? In respect of plastic material it is sufficient to call attention to the fact that the development of sucrose does not begin in the plant until it is far on the road to maturity. To this it may be objected that its accumulation does not begin until this period, and that what is formed earlier in its history is a really plastic material used in the development of other tissues. Had I time I might show, I think, conclusively, that the presence of the sucrose as a plastic material is not probable. Is it a reserve material? The sucrose which is deposited in the seeds of plants, in tubers like the sugar beet, and in sugar-cane, doubtless is a true reserve material and by its decomposition helps the growth of the succeeding plant. But the sucrose in sorghum seems to have no such function. It can in no way aid the incipient growth of the next plant, for that plant grows from a seed. As far as any use in the economy of the plant is concerned, it appears to be absolutely worthless. It is true that in the case of "suckering," the sucrose in the cane may suffer loss, but "suckering" is not always a natural growth; it is adventitious and is always detrimental to the proper maturity of a plant.

It seems, therefore, that the sucrose in sorghum is purely a waste material—as much so as an alkaloid or a resin.

In the cases where sucrose is a true reserve material, as in seeds, in tubers, and in sugar-cane, we find there is no tendency for it to disappear until the needs of the new plant require it. The sucrose remains, for instance, unchanged in the sugar beet until the new growth begins. The same is true in a higher degree of the sucrose in seeds. The fact, therefore, that in sorghum all traces of sucrose may disappear in a few days shows that its office is radically different.

As a result of my investigations I will say that the development of sucrose in sorghum is an accidental function, or rather an adventitious function. It goes on usually *pari passu* with the formation of the starch in the grain and the content of sucrose in the plant, and its quantity is at a maximum at the time the starch formation is completed. In the sugar-cane the sucrose appears to be not only reserve, but also plastic material. In the upper part of the cane the content of sucrose is much less than in the lower, showing that in the region of most active growth the sucrose may suffer decomposition and help in the formation of proteid. (I wish to add here that the only way in which the plant can use sucrose for the formation of other bodies or for working it into living tissues is by thus getting it into protoplasm.) On the other hand the content of sucrose in sorghum is sensibly the same in all parts of the cane, being just as great at the top near the place of most rapid starch storage, as it is near the base. It is not strange, therefore, if it be true that the production of sucrose is only the expression of the exuberant vitality of the leaf of the sorghum, that the greatest variations should be met with the content of sucrose. These variations are not confined to different varieties or to different fields but are found in the same variety in different canes growing in the same hill, and which, therefore, have been subjected to precisely the same conditions of culture and weather.

In ten successive analyses of sugar beets made two years ago, I found no greater variation than one per cent. in sucrose. The same was true of ten successive analyses of sugar-canes I made last month, November, 1886. On the other hand, any ten successive analyses of sorghum canes, made last October, will show a variation of six per cent.

I have not the time here to cite all the instances I have noticed which illustrate the principles set forth above. They number hundreds. Without a record of these analyses, however, the fact clearly appears that the chief cause of variation is found in the accidental or adventitious nature of the formation of the sucrose—in other words, its independence of the life history of the plant. When, however, the sucrose has once been formed, as in a mature cane, it is subject to sudden variations. Sudden changes in the weather, severe frosts, followed by warm weather, or simply standing dead ripe, often cause a rapid disappearance of the sucrose. It is first converted into invert sugar and this quickly disappears by fermentation.

When the canes have been cut also, if they be expressed at a temperature of a warm September day, the sucrose is rapidly inverted. This inversion is not due to the action of the acids which the sap contains, but is produced by a special ferment, probably *invertin*, or some similar substance.[4]

These variations in the content of sucrose, are, as I intimated at the beginning, the chief obstacles now in the way of the successful introduction of a sorghum sugar industry into this country. The last one is easily avoided by promptly working the cane as soon as it is cut. The first one can

[4]Duclaux, Compt. rend, 103, p. 881, has shown that sunlight is capable of inverting a solution of sucrose.

only be overcome by the scientific agronomist, aided by the best practical botany and chemistry.

Since sending the above paper I have received the *Revue Scientifique*, of February 5, 1887, containing a notice of the observations of Girard on the production of carbohydrates in plants. This author definitely confirms my statements in respect of the independent formation of sucrose in leaves. The reviewer says:

> "Les expériences de M. A. Girard mettent hors de doute que les limbes fabriquent alors des saccharose et des sucres réducteurs."

M. Girard shows the possibility of leaves developing starch from sucrose, but there appears to be no evidence that the reverse of this operation takes place.

Notes on Umbelliferæ of E. United States. II.

JOHN M. COULTER AND J. N. ROSE.

(WITH PLATE II.)

ANGELICA L.—Fruit strongly flattened dorsally, broadly winged at the commissure: carpel with 5 strong primary ribs, each with a group of strengthening cells,[1] the 2 lateral extended into broad wings, distinct from those of the other carpel, forming a double-winged margin to the fruit: oil-ducts one to several in the intervals or indefinite, 2 to 10 on the commissural side (figs. 14–18).—Stout perennials, with ternately or pinnately compound leaves, large terminal umbels, scanty or no involucre, small many-leaved involucels, and white or greenish flowers.—Incl. *Archangelica* Hoffm., excl. *A. Gmelini* DC.—Archangelica is referred to Angelica by Maximowicz, Bull. Acad., Petersb., 19. 273. The only characters serving to separate Archangelica from Angelica break down. The number of oil-ducts in the intervals, while usually one in Angelica, in Angelica Curtissii may be two, or even three, as well in the dorsal intervals as in the lateral; while in Archangelica hirsuta the oil-ducts may be reduced to one or two in the intervals. The generic relation of neither of these species can be determined by any character drawn from the oil-ducts, and plac-

[1] In January GAZETTE, p. 14, third sentence from bottom, in contrasting the characters of Angelica and Conioselinum, the last clause ("especially conspicuous under the lateral ribs") might be understood to refer to Conioselinum. It refers to Angelica.