yuccal and *pyrophaeal*. An examination of the contents of each extract showed a different quantitative and qualitative result.

Saponin was found in all parts of the plant.

Many of the above facts have been collected from the investigations of others. I have introduced these statements, selected from a mass of material, as evidences in favor of the view stated at the beginning of this paper.¹ My own study has been directed toward the discovery of saponin in those plants where it was presumably to be found. The practical use of this theory in plant analysis will lead the chemists at once to a search for those compounds which morphology shows are probably present.

I have discovered saponin in all parts of the *Yucca angustifolia*, in the *Y. filamentosa* and *Y. gloriosa*, in several species of agave, and in plants belonging to the leguminosæ family.

The list² of plants in which saponin has been discovered is given in the note. All these plants are contained in the middle plane of Heckel's scheme. No plants containing saponin have been found among apetalous groups. No plants have been found containing saponin among the lower monocotyledons.

The plane of saponin passes from the liliaceæ and allied groups to the rosales and higher dicotyledons.

Saponin belongs to a class of substances called glucosides. Under the action of dilute acids, it is split up into two substances, glucose and sopogenin. The chemical nature of this substance is not thoroughly understood. The commercial³ product is probably a mixture of several substances.

This complexity of chemical composition of saponin is admirably adapted for the nutrition of the plant, and it is associated with the corresponding complexity of the morphological elements of the plant's organs. According to M. Perrey,⁴ it seems that the power of a plant to direct the distribution of its carbon, hydrogen, and oxygen to form complex glucosides is indicative of its higher functions and developments.

The solvent action of saponin on resins has been already discussed. Saponin likewise acts as a solvent upon barium sulphate and calcium oxalate, and as a solvent of insoluble or slightly soluble salts would assist the plant in obtaining food, otherwise difficult of access.

Saponin is found in endogens and exogens. The line dividing these two groups is not always clearly defined. Statements pointing to this are found in the works of Haeckel, Bentham, and others.

Smilax belongs to a transition class, partaking somewhat of the nature of endogen and of exogen. It is worthy of note that this intermediate group of the sarsaparillas should contain saponin.

It is a significant fact that all the groups above named containing saponin belong to Heckel's middle division.

It may be suggested that saponin is thus a constructive element in developing the plant from the multiplicity of floral elements to the cephalization of those organs.

It has been observed that the composite occurs where the materials for growth are supplied in greatest abundance, and the more simple forms arise where sources of nutrition are remote. We may gather from this fact that the simpler organs of plants low in the evolutionary scale contain simpler non-nitrogenous chemical compounds for their nutrition.

The presence of saponin seems essential to the life of the plant where it is found, and it is an indispensable principle in the progression of certain lines of plants, passing from their lower to their higher stages.

Saponin is invariably absent where the floral elements are simple; it is invariably absent where the floral elements are condensed to their greatest extent. Its position is plainly that of a factor in the great middle realm of vegetable life, where the elements of the individual are striving to condense, and thus increase their physiological action and the economy of parts.

It may be suggested as a line of research to study what are the conditions which control the synthesis and gradual formation of saponin in plants. The simpler compounds of which this complex substance is built up, if located as compounds of lower plants, would indicate the lines of progression from the lower to the saponin groups.

In my paper⁵ read in Buffalo at the last meeting of the American Association for the Advancement of Science, various suggestions were offered why chemical compounds should be used as a means of botanical classification.

The botanical classifications based upon morphology are so frequently unsatisfactory, that efforts in some directions have been made to introduce other methods.⁶

There has been comparatively little study of the chemical principles of plants from a purely botanical view. It promises to become a new field of research.

The leguminosæ are conspicuous as furnishing us with important dyes, e. g., indigo, logwood, catechin. The former is obtained principally from different species of the genus *Indigofera*, and logwood from the *Hæmatoxylon* and *Saraca indica*.

The discovery⁷ of hæmatoxylin in the *Saraca indica* illustrates very well how this plant in its chemical, as well as botanical, character is related to the *Hæmatoxylon campechianum*; also, I found a substance like catechin in the *Saraca*. This compound is found in the *acacias*, to which class *Saraca* is related by its chemical position, as well as botanically. Saponin is found in both of these plants, as well as in many other plants of the leguminosæ. The leguminosæ come under the middle plane or multiplicity of floral elements, and the presence of saponin in these plants was to be expected.

From many of the facts above stated, it may be inferred that the chemical compounds of plants do not

occur at random. Each stage of growth and development has its own particular chemistry.

It is said that many of the constituents found in plants are the result of destructive metabolism, and are of no further use in the plant's economy. This subject is by no means settled, and even should we be forced to accept that ground, it is a significant fact that certain cells, tissues, or organs peculiar to a plant secrete or excrete chemical compounds peculiar to them, which are to be found in one family, or in species closely allied to it.

It is a fact that the chemical compounds are there, no matter why or whence they came. They will serve our purposes of study and classification.

The result of experiment shows that the presence of certain compounds is essential to the vigor and development of all plants and particular compounds to the development of certain plants. Plant chemistry and morphology are related. Future investigations will demonstrate this relation.

In general terms, we may say that amides and carbohydrates are utilized in the manufacture of proteids. Organic acids cause a turgescence of cells. Glucosides may be a form of reserve food material.

Resins and waxes may serve only as protection to the surfaces of plants; coloring matters, as screens to shut off or admit certain of the sun's rays; but we are still far from penetrating the mystery of life.

A simple plant does what animals more highly endowed cannot do. From simplest substances they manufacture the most complex. We owe our existence to plants, as they do theirs to the air and soil.

The elements carbon, oxygen, hydrogen, and nitrogen pass through a cycle of changes from simple inorganic substances to the complex compounds of the living cell. Upon the decomposition of these bodies the elements return to their original state. During this transition those properties of protoplasm which were mentioned at the beginning, in turn, follow their path. From germination to death this course appears like a crescent, the other half of the circle closed from view. Where chemistry begins and ends it is difficult to say.—*Jour. Fr. Inst.*

NEW METHOD FOR THE QUANTITATIVE DETERMINATION OF STARCH.

A. V. ASBOTH.

THE author maintains that unsatisfactory results are obtained in determinations of starch when the method employed is based upon the inversion of sugar, formed as an intermediate product, since maltose, dextrose, and levulose are partly decomposed by boiling with dilute

acids. He proposes to replace the methods hitherto employed by one which depends upon the formation of a barium salt of starch, to which he assigns the formula $\text{BaO.C}_6\text{H}_{10}\text{O}_5$. This salt is sparingly soluble in water and insoluble in dilute alcohol.

In making a determination a weighed quantity of starch is saccharified with water, then mixed with an excess of normal baryta solution, dilute alcohol added to make up to a certain volume, and, after the precipitate has settled, the excess of baryta is titrated back with acid.

The author also describes the apparatus he employs for storing and titrating with baryta solution. The latter is contained in the bottle, A, and the drying tube attached to the neck of the same is filled with quicklime. The burette, B, which is in direct connection with the bottle, may be filled with the solution by opening the stop cock, and the small drying tube, n, is filled with dry KOH, thus preventing the entrance of any CO_2 . Numbers are appended which seem to testify to the excellence of the method employed. The author finally gives a detailed account of the entire analysis of various cereals.—*A. R. in Jour. Soc. Chem. Indus.*

SYNTHESIS OF THE ALKALOIDS.

IN the note on the constitution of alkaloids in a recent issue, we referred more especially to what we may term the less highly organized bases. Most of our knowledge, as we now have it, regarding such alkaloids as muscarine and choline has been acquired during the past dozen years. This is not exactly the case with the higher groups of alkaloids—the derivatives of pyridine and quinoline. It so happens that the oldest alkaloids are in these groups. They have, almost necessarily, been subjected to a longer period of attack, but the extreme complexity of their molecules, and the infinite number of differing parts or substances into which these molecules split up when attacked, are the main cause of the small progress which has been made in this department. All, however, yield one or more bodies or bases in common, while each has its distinctive and peculiar decomposition product. For exam-

ple, cinchonine and quinine both afford the basic quinoline under certain conditions, but on oxidation of cinchonine, an acid—cinchoninic acid ($\text{C}_{10}\text{H}_7\text{NO}_2$)—is the principal body formed, while in the case of quinine, quininic acid ($\text{C}_{10}\text{H}_7\text{NO}_2$) is the principal product. The acquirement through experiment of such knowledge as that is, however, so much gained. We find, indeed, that obstacles are gradually being cleared away, and the actual synthetic formation of such alkaloids as piperidine and coniine is a proof that the chemist is on the right track in studying the decomposition products, and building up from them, theoretically, bodies of similar constitution. It is noteworthy that the synthesis of the alkaloids has led to some of the most brilliant discoveries of the present day, especially in the discovery of dye stuffs. Many of our quinine substitutes, such as thalline, for example, are the result of endeavors to make quinine artificially. If there is romance in chemistry at all, it is to be found certainly in this branch of it, which is generally considered the most uninteresting and unfathomable. We may take piperidine and coniine as examples of the methods followed in alkaloidal synthesis; these are pyridine bases. Pyridine has the formula $\text{C}_5\text{H}_5\text{N}$, that is, it is benzene with CH replaced by N. The relationship between these and piperidine is seen in the following formulae:

If we introduce six hydrogen atoms into pyridine, we convert it into piperidine. Ladenburg succeeded in so hydrogenizing pyridine by acting upon an alcoholic solution with sodium, and from the base which was formed he obtained a platinochloride which agreed with the similar double salt of piperidine. He has also prepared it from trimethylamine cyanide by the action of sodium. Pentamethylenediamine is the principal intermediary product, and this gives piperidine when distilled with superheated steam. He has proved that the alkaloid so obtained is identical with that prepared from piperine. Another curious point which Ladenburg has lately proved is that cadaverine (one of the products of flesh decomposition) is identical with pentamethylenediamine, and that its imine is the same as piperidine. The synthesis of coniine by Ladenburg is one of the most notable achievements of modern chemistry. He at first supposed that this alkaloid was piperidine in which two hydrogen atoms were replaced by the isopropyl radical (C_3H_7), its formula being taken as $\text{C}_8\text{H}_{13}(\text{C}_3\text{H}_7)\text{N}$. But he has since changed his view, as will be seen from what follows. In its synthesis 1,000 grammes of picoline were first converted into alphapicoline, 380 grammes being obtained. This was heated with paraldehyde, whereby it was converted into allylpyridine (48 grammes), and this by reduction with sodium yielded alpha-propylpyridine, a body in almost every respect identical with coniine. The more important difference was its optical inactivity, but he succeeded in splitting up a solution of the acid tartrate of the base by means of *Penicillium glaucum*. Crystals separated which had a dextro-rotatory power of $[\alpha]_D = 31^\circ 87'$ as compared with the $[\alpha]_D = 13^\circ 79'$ of natural coniine. This brief account conveys but a faint idea of the difficulties which were encountered in these researches. Optical methods of examination have proved of great value, and are destined to play an important part in such work.

Among the most complex alkaloids are those of the quinine group. As yet chemists have got no further with these than the oxidation products; but the study has afforded us several new antipyretics and many interesting facts. It has been found, for example, that artificial quinine-like bodies, which fluoresce and give the green color with chlorine water and ammonia, have antipyretic properties like quinine, but their secondary effects are so pernicious as to prevent their use. If, however, such bodies are hydrogenized or methylated they lose their fluorescing property, do not give the green color, and their secondary effects are removed. Knowledge of these facts led to the discovery of thalline. It is prepared from paraquinanisol, one of the objectionable bodies, by reduction with tin and hydrochloric acid. The following formulae show the constitutional relationship of these compounds:

It is evident from the difficulties which have been encountered in this department of chemistry, and more especially from the costly nature of the work, that it will be many years before it will influence the manufacture of alkaloids from the drugs which yield them. Ladenburg has synthesized coniine, but he has not yet ventured to assert that his product will replace the natural alkaloid.—*Chem. and Druggist.*

THE *Southern California Advocate* reports another magnificent donation of lands to the University of Southern California by Mr. D. Freeman, the owner of the Centinella ranch near Los Angeles—six hundred thousand dollars in all given to found a school of applied sciences, \$100,000 for building and apparatus and \$500,000 for endowment. The buildings will be in the vicinity of Inglewood, the new and beautiful town on the Ballona branch of the California Central.

¹ For further facts confirming this theory, see "Comparative Chemistry of Higher and Lower Plants," By H. C. De S. Abbott. Amer. Naturalist, August, 1887.

² Different genera and species of the following: Ranunculaceæ, Berberidaceæ, Caryophyllaceæ, Polygalaceæ, Bromeliaceæ, Liliaceæ, Smilacaceæ, Yuccaceæ, Amaryllidaceæ, Leguminosæ, Primulaceæ, Rosaceæ, Sapindaceæ, Sapotaceæ.

³ Robert: Chem. Ztg.

⁴ Compt. Rend., xciv, p. 1124.

⁵ Bul. de la Soc. Chim.

⁶ "Yucca angus." Trans. Am. Philos. Soc., Dec., 1885.

⁷ Botanical Gazette, October, 1886.

⁸ Borodin: Pharm. Jour. Trans., xvi, 369. Pax. Firemy: Ann. Sci. Nat., xiii.

⁹ H. C. De S. Abbott, Proc. Acad. Nat. Sciences, Nov. 30, 1886.