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THE LIVING BELLADONNA.

(*Continued from p. 836.*)

METABOLISM.

The belladonna, in common with other green plants, receives a small portion of material from the soil in the form of salts dissolved in the water absorbed. The greater portion of the supply, however, comes from the air. This is not the food of the plant, but the raw material—"the makings of food." Before these materials can become food, much work must be expended upon them.

The food prepared by the plant is not immediately used up, the excess over immediate requirements being stored in various parts of the plant for subsequent consumption. The stored food passes through processes of change and digestion associated with a process of assimilation. A constructive process—anabolism, a destructive or breaking down process—catabolism.

The amount of food material taken in by the belladonna plant from the soil is very small. One hundred grains of the green plant will give only about one grain of mineral matter (ash).

When subjected to analytical processes, the belladonna plant has been found to contain the following elements: hydrogen, carbon, nitrogen, oxygen, sulphur, potassium, calcium, phosphorus, chlorine, sodium, magnesium, iron, aluminum, silicon and, in rare instances, copper.

One would not attempt to build up a plant structure from the "humpty-dumpty" array of elements found in belladonna. Each of the several elements noted renders a service to the organism. The activity of the life elements we now know is connected with the forms of electric energy called catalysis.

"The electric action and reaction of the elements according to modern views are the chief phenomena of the internal functions of life, developed in the presence of oxygen by the energy either of the heat of the earth or sun, or both the heat and light of the sun."—Osborn.

It is beyond our ken to understand why, in the interplay of the foregoing elements, at one time there comes a rose and at another time a solanum.

Carbon, hydrogen, oxygen and nitrogen are elements common to all plants. Where and how these four elements get together to evolve the principles peculiar to the *solanums*, or why at one time these elements make up as atropine, and at another hyoscyamine or hyoscine, and so on, we ask—and await the answer.

Through the circulatory mechanism of the plant a continuous supply of nutritive material is carried to every point where needed. This nutritive matter is in the form of raw material.

The old idea of plant nutrition was a stream of ascending and descending sap through the plant organs. In our present knowledge we find that this takes place through diffusion, which is constantly occurring between contiguous cells in all directions.

Food substances, carbohydrates for example, are found in a soluble traveling or nutritive form—sugar, or in a storage form—starch. By this process food material is translocated from one point to another, to suit the condition of the plant's life.

In the belladonna plant we find at certain points of its structure a greater abundance of carbohydrates in the form of starch or sugar than at other points. The transport of proteins, including alkaloidal bodies, follows a like course. They are found at various points of the translocatory tracts.

In the life history of the narcotic *solanums*, including belladonna, we find the alkaloidal bodies present in greater proportion at one period than at another. The alkaloidal bodies appear in this light as a part of the nutritive material of the plant—food for the plant, poison for man.

In the case of belladonna and other plants, surplus food is stored in the root for use of the new plant. The surplus food of the plant exists either in a condition for traveling or for storage. In the carbohydrates the surplus exists as sugar, glycerine or as starch. In belladonna, starch is the most abundant of the reserve food supply. The amount of starch present is dependent upon the period of vegetation. According to Brandes, first-year plant roots contain less starch in the spring than in the autumn. The older roots are rich in starch both in the spring and autumn, but contain less in summer.

Carbohydrates, other than starch, are found stored in the cells of belladonna, especially in the resting stage. Of these may be mentioned wax and oily substances, which are present in the seeds in sufficient quantity to impede propagation unless removed by solvents.

Nitrogenous materials, including the alkaloidal compounds, are a stored reserve in plants. The alkaloids are also found stored in the seeds of belladonna and other solanums.

Roots well filled with starch give a higher yield of alkaloid than those which are non-starchy. As the season of the growth of the plant wanes, the amount of alkaloid present in the leaf and stem declines, whereas the amount of alkaloid present in the root is increased. Hence, the growers gather the leaf at the flowering time, and the roots in the fall and winter, during the resting stage.

The herbalists, who were the fathers of pharmacognosy, taught that plant life was governed by the movement of the planets, and in digging roots and gathering herbs they were guided by the signs of the zodiac. They were not so far wrong, for we now gather the leaves and dig the roots of belladonna according to the almanac.

The process by which the reserve stores of food in the plant is fitted for transportation to, and utilization by the growing and developing plant cells, or from an insoluble to a soluble form, may be termed digestion, from its analogy to similar processes in the animal body.

In these processes of digestion, as carried on in the belladonna plant, we believe that the poisonous so-called alkaloids are elaborated.

The process of digestion in plants in part takes place in the protoplasm of the cell. It is carried out by agents secreted by the plant in the form of enzymes—soluble ferments.

Ordinarily, ferments are inactive at low temperatures. Their activity increases as the temperature is raised to their optimum point of action (30 to

The Belladonna Plant.

45° C.). Above this point they gradually become inactive, and at 60 to 75° C. their activity is destroyed.

In the belladonna plant the enzymes are active at low temperatures. The seeds will sprout at points slightly above 5° C., and the plant will grow at an air temperature of 10° C. The whole round of changes taking place in the living plant is spoken of as metabolism.

The protoplasmic construction process is described as anabolic. The processes which are concerned in the decomposition of protoplasm, are termed catabolic.

In the anabolic processes the protoplasm is constantly reconstructing itself, using up nutritive substances in the construction of new cells—growing. Side by side with the anabolic processes there is going on a decomposition of the protoplasm, the products of which are again used in the reconstruction of the protoplasm, or they may remain unaltered. So long as the plant is living, the protoplasm is continuously undergoing reconstruction and decomposition.

Among the products of catabolic change are the cell walls of woody or corky fibre. In the belladonna plant this woody fibre is not apparent until after the first year's growth, and then only in small amounts.

A plant, in the ordinary sense, has no excreta. Whatever it absorbs from the soil, except water, it retains. The matter deposited in the bark of trees and in leaves about to be shed may, however, be considered as dead matter—excreta.

Many substances formed during the catabolic changes seemingly have no direct bearing upon the life processes. These are termed by-products of metabolism, and are varied in character, some being nitrogenous and others not. In the study of the belladonna plant we are greatly interested in the nitrogenous by-products—the alkaloids.

It has not been found that alkaloids are in any way able to minister to the nutrition or growth of the plant, though their nitrogen is an organic combination. If the plant is supplied with nitrogen solely in alkaloidal combination, it is starved.

In the belladonna plant the alkaloid is stored in the seed in fairly large proportion. There is an apparent decrease of alkaloid during germination. This would seem to show that the alkaloid formed a part of the nutriment of the seedling.

If we consider the alkaloids as excretions, we are met with the fact that they decrease in the leaf and stem of the plant as these parts prepare to be cast off. The alkaloids increase in the roots as they approach the so-called resting stage.

The odorous substances of the belladonna plant may be classed as by-product.

The products of metabolism, or plant chemistry, in a simple plant like belladonna, are quite formidable.

They include starch, sugars, including honey and saccharates, cellulose, gums, wax, resins, mucilages, asparagin, albumin.

Coloring matters: chlorophyl, anthocyanin purple, xanthophyll yellow, atrosin coloring principle of the root.

Alkaloids: atropine, hyoscyamine, belladonine, atropamine, apatropine.

Acids: (chiefly combined with bases), acetic, malic, chrysatropic (flourescent), succinic, prendatorin (Brandt), phyteumscolla (Brandt).

Salts: potassium, sulphate, nitrate, phosphates, chlorides, hydrochlorates, oxalates, malates magnesium malate, sodium chloride, phosphate.

Ammonium salts: calcium malate, oxalate. Quite characteristic of belladonna is the presence of clusters of crystals of calcium oxalate in cellular spaces of the leaf, apparently walled off from the vital processes of the cells. Odoriferous principles in the plant as a whole, and aromatic bodies in the flower.

It is possible that some of these substances may be formed as a result of analytic manipulation, but it is quite true that the products of cellular activity in a plant are complex and numerous. Some of the products enumerated are peculiar to the solanums, others seem to belong solely to belladonna.

PROTOPLASM.

Microbes, kings, cabbages, roses, belladonna and all living creatures, seem to be built up of a curious slime stuff—protoplasm.

A plant like belladonna seems to be a multiplication of jelly-like cells—protoplasm—strung together to form root, stem, branch, leaf and flower. Through some peculiar arrangement of cells, and through some peculiar power therein, comes a solanum and a belladonna.

No one has gotten very far in solving the riddle of the protoplasmic cell. The chemist can make little headway in attempting to pull protoplasm apart. At the first touch, its life is destroyed, the structure and substance are changed.

About all we know is that it is colloidal. Under the microscope there is not much to be seen—a droplet of soft jelly, cloudy with specks. Perhaps some day we may be able to see the arrangement of the atoms in the molecules, measure the play of the corpuscles, and witness the working of interatomic energy in the living protoplasm. But this seems far away. Meanwhile, all we can see is a drop of jelly.

Somewhere in the cell cavity there is found a peculiar portion known as the nucleus.

The protoplasm apparently is the center of all the activities which the plant manifests. It assimilates food, it can build up dead matter into living molecules, and transform foreign matter into substance like its own. It carries out all of the processes necessary for life, growth and reproduction. It receives the impressions and regulates the responses which the plant makes to environment. "We might go so far as to say that protoplasm can think."

The whole life movement of the plant, internal and external, is regulated and controlled through its protoplasmic "slime."

Physically and chemically we could say that the "life stuff" of a bacterium, a lily or a solanum, a whale, a worm or a philosopher, was alike--but there must be a vast difference.

Osborn ("Origin and Evolution of Life") attributes the remarkable response of the plant organism to environmental influence to physicochemical causes, centering in the nuclei or "heredity-chromatin."

Certain of the solanums, and in particular the belladonna plant, have been characterized as "dull and sluggish." It has been intimated that some of their characteristics, such as tendency to shady, protected surroundings, unattractive appearance, and rather repellent odor, are indications of a lack of characters present in many other plants.

ENVIRONMENT.

We know that the protoplasm seems peculiarly influenced by environment; it does not spontaneously adapt itself to changed conditions.

It has taken long ages for belladonna to obtain a foothold in the few regions which are now its habitat. It has come to be belladonna through a long struggle against the powers of earth and sky. In the process of sorting and sifting it has come out belladonna.

The tendency to change, to mutate, to cross-breed, does not seem to be present in belladonna. In this respect, so far, it has resisted man's efforts to "improve" by breeding or cultivation. It has resisted extinction, even meeting the ruthless efforts of the modern "root diggers."

While its range is limited, it seems to have well-established powers of adaptation. It can maintain existence against many odds. It has manifest control over food and water supplies, atmospheric and physiochemical energies. It has power to maintain interaction with nature, propagate itself, breed true. It lives, thrives and produces alkaloidal substances with unfailing regularity.

Osborn ("Origin and Evolution of Life") formulates the fundamental biologic principle of development as follows:

"In each organism the phenomena of life represents the action, reaction and interaction of four complexes of physiochemical energy, namely those of (1) the inorganic environment (air, light, soil, moisture); (2) the developing organism (protoplasm and body chromatin); (3) the germ or heredity chromatin, and (4) life environment. Upon the resultant actions, reactions and interactions of potential and kinetic energy in each organism, selection is constantly operating wherever there is competition with the corresponding actions, reactions and interactions of other organisms."

The belladonna has come to be, and remains, belladonna through a webwork of life energy. With a variation of the environment, a modification of form structure and other characteristics would be expected.

Certain of the allied solanums are climbing plants, some of the closely related Daturas are shrubby under one environment and attain to tree form amid other surroundings. Belladonna might do the same.

Differences have been observed in belladonna growing in France and Spain as compared with that found in the central regions of Europe. The structure of the belladonna plant growing in the Vosges and Black Forest differs from that growing in the Austrian Alps.

In England, difference of structure in the belladonna plant occurs between plants grown in the Northern or Southern regions, and in specimens growing in the open field, in a chalk pit, or under the walls of a ruin.

In the American cultivations of belladonna a difference of form and size of plant, leaf, stem and root, according to the locality where grown, was noted.

Through the influence of changed environment, plus other complexes, there has arisen from ancestral stock the several species of Atropa belladonna now known.

To the influence of environment, in a greater or lesser degree, is due the size of the belladonna plant, the size of the leaf, the size and the shape of the root structure. Environment also, in a measure, has an influence upon the fertility of the seeds, and upon the rapidity of growth and maturity.

There is much that is not yet clear as to the influence of climate upon plant life, and of plant life upon climate.

During the long-gone geologic ages, great forests spread over the world, stabilizing the climate. Man, by destroying the forests, has changed the climate of vast regions of the earth's surface.

We know that a few thousand years ago there was a greater luxuriance of plant life in Europe and in Asia than prevails to-day. We can but believe that our narcotic solanums have been affected in this change.

The influence of environment upon the alkaloidal constituents of the narcotic solanums, we dare not attempt to surmise.

Erlich stated that "environment might so affect the individual metabolic processes as to give rise to modifications of the constitutions of proteins and other vital molecules, sufficient to cause not only physiological and morphological differentiation in the individual, but also become manifested functionally and structurally in the offspring."

The presence of hyoscyamine, atropine, hyocine, daturine and like bodies in the closely related species of narcotic solanums may, in a measure, result from the influence of environment through the ages.

Environment excites a far-reaching influence on the life and growth of a plant. But environment is not the sole factor in the making of a solanum or a belladonna. The germ lies beyond and behind the environment. Through the germ plasm it inherits and transmits the power to adapt itself to changing environment. Through the germ plasm and adaption to environment we may hope that it is moving forward and onward—perhaps to a higher order of mydriatic solanums, a better belladonna.

GROWTH.

The belladonna is an herbaceous perennial. When started from the seed it germinates very slowly. In a cold-frame or greenhouse, under favorable conditions, from six to eight weeks are required. In our climate the seed of belladonna will not germinate when sown in the open ground.

With the swelling of the seed and bursting of the shell, the very fine hair-like root grows downward, and the embryonic stem bearing the cotyledons moves slowly upward. The rather shapeless, veinless leaves unfold, and take on a green color. Slowly new buds are developed at intervals on the stem, from which new leaves are formed.

The movement of growth is slow. The seedlings are very tender and fragile, halting and succumbing under adverse influence of surroundings. The growing and developing plant gradually takes on shape, stems lengthen, branching at intervals. Guided seemingly by a controlling intelligence, short stalked, oval, acutely tapering leaves form alternately below, in pairs above.

The newly formed leaves appear almost tissueless, of a light translucent green, gradually thickening and forming innumerable veins, membranes and cells, on which microscopic hairs appear.

Seemingly sudden, but really in regularity as to stage of growth, at some budding points short-stemmed flowers instead of leaves form. Embryo sacs, sepals, pollen grains, stamens and pistils appear instead of ordinary leaves. Then comes the fruiting stage. The ripened fruit carrying the fertilized seed completes the cycle of growth.

The belladonna plant seems capable of growth in all directions up to the final ripening of its purple berry.

We lack exact information as to the growth of drug plants in respect to influence of conditions which affect their rate of growth, increase in size, weight and more than all—increase or decrease in their medicinal constituents.

With respect to belladonna, and most other drugs, we have only a few general agricultural conclusions. It has been recorded that in certain seasons the crops were either good or bad, attributed at times to excess or lack of moisture, heat, etc.

Accurate methods now available for recording the effect of light, temperature, moisture and other external conditions upon the growth of plants, have not been applied to belladonna. A few crude records made during the author's cultivation of this plant, seemed to indicate that there were some notable exceptions in regard to its growth when compared with other plants.

Belladonna will grow at 30° F., and its growth will increase up to 70° to 75° F. Above this temperature growth diminishes. Belladonna is evidently habituated to comparatively moderate temperatures. In common with other plants, it grows faster in lessened light, or even in darkness. Experiments made by the author showed that growth during the night was notable, especially if the nights were not too cool, and there was a fair amount of humidity. When shaded, in the manner followed in growing tobacco and pineapple, growth of stem and leaf increased.

Both light and heat increase transpiration, and thus have a tendency to check actual growth.

We have assumed, perhaps erroneously, that the purple color on the stem and leaf stalk of belladonna, in some degree modified the action of light.

Adequate supply of water is, of course, essential to the processes of life and growth in all plants. There must be water to swell new formed cells. Food is transported by and through water. The process of metabolism is carried on in solution. Humidity of the atmosphere checks transpiration and evaporation of water. Growth increases with atmospheric humidity.

There are many conditions which affect the growth of a plant like belladonna, but the influences of temperature, light and humidity are outstanding.

The rate of growth through the life of the plant is not uniform. The new sprout from the root or the seedlings grows slowly at first; having attained a good start, the rate of growth is more rapid. The stems, branch, leaves and flowers form, and growth proceeds up toward fruiting, after which the growth is slower.

Increase in height, in size of branches or leaves, is not necessarily an increase in weight of solid structure. Young growing plants contain above ninety per cent of water.

The root of the belladonna plant increases markedly in weight as the reserve starch food is deposited, and the stem has attained its growth and begins to die down. Branches and stems cut off in gathering a crop of leaves, especially if done before fruiting, are rapidly replaced. Thus two and three crops of leaves can be harvested in one season.

In the American climate the belladonna plant does not grow rapidly, nor attain a large size. Plants from seedlings reach from one and a half to two feet the first year. Plants sprouting from roots may attain a height of three feet, branching to a spread of two and one-half feet. In succeeding years, plants from the root may increase slightly in height, but never reach much above these dimensions.

The belladonna plant is an herbaceous perennial. In a large measure it stores its food in its parts underground, from which new stems, flowers and fruit are produced the next season. As the storage proceeds, the top dies. Except in the top of the root, or corm, no woody fibre is formed. The woody structure increases only slightly with the age of the plant.

Apparently there is no marked symmetry in the structure of the belladonna plant. While there is a general type, no two are alike in structure. Injuries during growth and adaptive adjustment, alter greatly the form, size and shape of structure.

In wooded thickets, amid weeds and shrubbery, a seedling will send up at an angle, a single spindle-like stem, without branches and with few leaves, to reach a place in the light and air. Stems ererging from the rhizome usually go out at an angle instead of straight upward, seemingly so that its branches and leaves may expose a greater surface to the atmosphere.

There are apparent disturbances of growth through internal causes, the nature of which is unknown, whereby there is irregularity of growth, a stunting and unusual arrangment of shape and form of stem and branch, and other odd modes of growth.

The root of the plant, while ordinarily in the first season a single tap-root, will branch and bend to avoid stones or other obstructions, go deeper, or branch sidewise to reach favorable soil. In older plants it will throw out branches where necessary to give the plant a firmer hold.

From year to year the root slowly increases in size, each year adding to its woody cortex. Very old roots tend to take on a cork-like, spongy structure. Except in the rhizome, the belladonna plant forms no permanent tissue.

Only the first stages of food transformation are carried on in the root of the growing plant. The real laboratory lies along the canals of the stem and the leaf.

The juices of the growing plant are acid—said to be acid potassium sulphate, a substance that stimulates osmosis.

In the root of the belladonna plant, starch and the materials needed for the young shoots, are stored through the winter resting stage. This so-called resting stage is not one of inactivity—life proceeds slowly, raw supplies are still taken by the cells, starch and other products received from the stem and branches are slowly transformed into assimilable material, and digestion goes on at a retarded pace.

During the "resting stage" there is an activity looking toward and preparing the starting of shoots, which will be the beginning of a new growth of the stem and branches. The rhizome corm, or undergrowth, on the top of the root is the point from which the renewing stems start.

The alkaloid is present in the root and corm, due in part to the accumulation in the root as the top dies down and sends the alkaloidal bodies to the root. Tests show a slightly greater proportion of alkaloid at the end of the resting stage than at the beginning, thus indicating that they are formed during this stage of the plants' existence.

The suggestion has been made that the poisonous principles are hoarded in the root as a protective against animals who might prey upon the structure. There is no record of any animal attacking the belladonna root. It is not of a nature to attract food-seeking animals, and would not necessarily poison them. The roots, however, are viciously attacked and destroyed by underground worms (cutworms), and the worm escapes unharmed.

REPRODUCTION.

It would be futile, even were the author competent, to attempt to give in detail the methods by which the plants of the group here under survey reproduce themselves.

The belladonna, like other plants of the higher type, reproduces new plants from seed. The formation of the seed begins in the flower.

In the flower, we see inside the purple-lobed bell five slender, curved stalks with rounded heads. These stamens or male parts are covered with pollen "dust," the element of fertilization. The female part a greenish stalk with a two-lobed head, carries the embryo seeds or ovules. At the base of the style are honey-bearing glands.

To reproduce a thrifty belladonna plant, the male pollen must be brought into contact with the female ovules of another plant. This pollen can be carried by the wind, as may be demonstrated by placing a moistened glass over the flower, and inserting the tip of a flower beneath, when the pollen dust will collect on the glass. But by such a process there would be a tremendous loss. Some plants are fertilized by the wind-blown pollen, but probably not the belladonna.

During the sunshine hours of summer, the honey bee, guided in part by the purple flower, but probably more so by the nectar odor, works his way to the innermost part of the flower, and taps the honey-bearing glands. His body carries the pollen grains to the next plant to be visited, and leaves them on the flowers' sticky stigma. This cross-fertilization is one of nature's many sublime accomplishments.

The pollen grains swell, send tubes of active living matter into the embryo sacs, the ovules are quickened, and as cell joins to cell a new plant is born.

In the embryo is packed all the inheritance of the parent (including alkaloid)—all that goes to make a belladonna plant. Under magnification, as it develops, we can see root, shoot, bud and leaf.

In a small enclosed embryo we have many seeds, enclosed in sac form—a berry, at first green, then in turn purple, with wine-like poisonous juice. The ripened fruit and seed dry, fall to the earth, and after a period of rest, the never-ending cycle starts anew.

BELLADONNA SEASON.

"To everything a season," says Ecclesiates. The rhythmatic life of plants is punctuated by the seasons.

With belladonna, in its home, the spring is the time when a fresh start is made. The seeds have been lying in the earth within their envelope; enzymic agents have prepared the food laid by the parent plant for sustenance of the embryo.

As the warm spring moisture seeps in, the seedlings emerge. A new belladonna is born! And there begins the delicate movement of stem and root, leading onward to a full-formed plant.

During the winter, the root of the old plant, buried under the soil, has formed buds on its corm, and transformed its stored food into active nutriment. With the coming of spring, rootlets take in moisture, pressure and action begins, the new stem shoots upward through the soil, the packed leaves of the bud unfold, take on green, and a vigorous belladonna stands before us.

To the lover of nature, the spring awakening or renascence of even so humble a plant as a belladonna, inspires at once a feeling of awe and inspiration. It comes swiftly, surely, gloriously—but is beyond our ken!

As summer comes on, the stem moves upward, branches and leaves take on full strength and maturity. Food is made and passed steadily to growing and storage points; flowers, fruit and embryos form; bees spread the fertilizing pollen;

the fires of life burn brightly—the belladonna is in its glory. Output and income of energy are at their height, in preparation for the seasons to follow.

In midsummer, flowers, green fruit and ripe fruit appear, scattered over the belladonna plant. When the plant stands in flower, its alkaloidal principles are formed, in the greater measure in the leaf.

Autumn is the time of ripening and preparation for the future. Growth slackens and stops; starch, sugar and alkaloid are transported to the root; berries ripen, dry and fall to the earth. The intense activity in stem and branch wanes; leaves and stem surrender their living matter to the plant which bore them.

The green color recedes, fades to brown and yellow, the structure dies and falls to the ground, is seized by bacteria and earth worms, to be made over into nourishing soil for the new plant which is to come. Seed and root are covered by the ashes of the dead top, in preparation for the renewed life of another season.

Winter is low tide in plant life. Activity slackens but does not cease. Within root and leaf slowly stored substances are changed. The embryo in the seed takes on shape, buds form on the root crown. Winter is likewise a time of winnowing, sifting and elimination. Weaklings in seeds and roots succumb, rot and are returned to the elements. The few that survive, among the many that perish, take on vigor for the coming season's eternal cycle.

ISOLATION OF THE OIL AND ALKALOIDS OF STAVESACRE SEED.

(Delphinium Staphisagria).

BY L. N. MARKWOOD.*

Following the investigation on *Delphinium consolida* (13) investigation of the seed of *D. staphisagria*, commonly known as stavesacre, was undertaken to isolate in pure form the oil and alkaloids in order to determine their insecticidal activity.

In the past century various reports of work on the alkaloids of the genus *Delphinium* mainly *D. staphisagria*, have been made. Among these the outstanding contributions have been made by Marquis (14), whose formulas for delphinine, $C_{22}H_{33}NO_{63}$, m. p. "above 120°," and the three other alkaloids he claims to have isolated have been widely copied in textbooks; by Kara-Stojanow (9), who ascribed to delphinine the formula $C_{31}H_{49}NO_7$, m. p. 191.8° (cor.); by Katz (10), who reported no formula or melting point but undoubtedly had the pure alkaloid and performed the first experiments on chemical structure; by Walz (17), who, having at his disposal 50 Gm. of crystallized delphinine (Merck), established the formula $C_{34}H_{47}NO_9$, m. p. 187.5° (uncor.); and by Keller (11), who made no determination of the formula but found the m. p. 187.5° (uncor.) and performed experiments on the constitution.

Since a large part of the success in obtaining pure alkaloids depends on the solvent for extraction, tests were made to determine the suitability of various solvents. Previous investigators had used as solvents alcohol, alcohol with acetic

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