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THE CHEMISTRY OF THE CACTACEAE.[1]

BY ERVIN E. EWELL.

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I. AN HISTORICAL RESUMÉ AND PRELIMINARY NOTE.

THERE is probably no more interesting family of plants than the *Cactaceae*. This interest is manifest among civilized and uncivilized peoples, old and young, scientific and unscientific. If there is one that does not feel this interest; if there is one that is not inspired with awe at the mere contemplation of the weird forms assumed by the numerous species of this great order, which includes giants and the tiniest dwarfs; if there is one that is not moved by the mysterious beauty of an opening blossom of the "night-blooming cereus," then let that one swallow one or more of the little buttons that we shall exhibit to you this evening and note whether or not he is susceptible to the more subtle and more powerful influence that he will find working from within. There is scarcely a housewife in the land that pretends to maintain a conservatory or a window garden without numbering one or more cacti in her collection. She would have no hesitation about pronouncing any member of the order a cactus, so marked are their characteristics; yet, when it comes to a more minute study for purposes of classification, botanists who have spent years in studying them are still disputing about them and have filled the literature of the subject with a host of synonymous names.

When we examine the chemical side of the subject, we find that our knowledge is still more imperfect. The fact that many of these plants are used for food and that their juices are drunk in place of water by the travellers in the arid regions where they grow in abundance, has caused them to be regarded as devoid of chemical constituents of greater importance than those that are to be expected in any of the innocent plants of humid regions. Various species have been used medicinally in the countries in which they grow. *Cereus grandiflorus* and a few allied species have attained a reputation in medical practice

[1] An abstract of this paper was read before the Washington Section of the American Chemical Society, April 9, 1896.

among peoples more advanced in the scale of civilization, and have consequently been made the subject of some chemical investigation. Their fresh juices produce irritation of the skin when locally applied, and preparations of them are administered internally as cardiac stimulants and for other purposes. The first article published in this country on the subject seems to have been one by A. F. Pattee, which appeared in the *Boston Medical and Surgical Journal* in 1867. O. M. Meyers published an article in the *New York Medical Journal* in 1891, in which he called attention to the value as a heart tonic of a preparation of *Cereus grandiflorus* called "cactina." This was claimed to be the active principle of the drug, but it was not stated whether it was alkaloidal, glucosidal, or of some other nature. Numerous papers quickly followed, containing reports of clinical experiments with this and other preparations of the drug. Some of these papers included brief reports of chemical investigations. Boinet and Boy-Tessier reported the finding of an alkaloid in this species.[1] G. Sharp[2] stated that he was unable to find either alkaloid or glucoside in the drug, and ascribed any active properties that it may have to the resin that it contains. He failed to obtain any marked effect from the drug itself, and took doses of forty and one hundred of the cactus pills, prepared from *Cactus Mexicana*, without result. This is practically all that has been done in the way of chemical investigation of this class of plants in recent years, excepting the species that we are to consider and a few species closely related thereto.

As far as I have been able to learn, three groups of persons have been especially active in the scientific study of the *Cactaceae* during the last decade: First, a group of persons at Berlin, the center of which is Dr. L. Lewin, whose earlier work has been reported in this country in a pamphlet published by Parke, Davis & Co., of Detroit, and in the *Therapeutic Gazette* for 1888; second, a group of persons at the Pharmacological Institute of the University of Leipsic, where the work has been conducted by Dr. Arthur Heffter; third, a group of persons in this city, centering in the Bureau of American Ethnology, and including

[1] *Bulletin général de Therapeutique, 1891*, 121, 343–349.
[2] *London Practitioner*, 1894.

as associates the Division of Chemistry of the Department of Agriculture for chemical studies, Drs. Prentiss and Morgan for the study of physiological properties, and the Botanical Division of the Department of Agriculture for the settlement of botanical questions. These more recent investigations have been directed toward one or more species of cacti that are used by the American Indians for ceremonial and medicinal purposes. This substance, known as "mescal buttons" in the commerce of our southwestern border and in Mexico as *peyote* or *pellote*, has been of commercial and medicinal importance in Mexico for many years, being mentioned by Spanish writers as early as 1790. It was included in the Mexican Pharmacopoeia of 1842, but has been omitted from the later editions. The species furnishing the "mescal buttons" is *Anhalonium Lewinii* (Hennings), for which the synonymous names are *Anhalonium Williamsii*, var., *Lewinii* and *Lophophora Williamsii*, var., *Lewinii*. There seems to be evidence that *Anhalonium Williamsii* also contributes to the supply of "mescal buttons" and *pellote*. This latter species is likewise burdened with an abundance of names, being known among botanists by the names of *Echinocactus Williamsii* and *Lophophora Williamsii*, in addition to the one just used to designate it.

For a detailed account of the use of the dried "buttons" by the Indians, I quote, by permission, from a recent article on the subject by Mr. James Mooney of the Bureau of American Ethnology:[1]

"About five years ago, while making investigations among the Kiowa Indians on behalf of the Bureau of Ethnology, the attention of the writer was directed to the ceremonial use of a plant for which were claimed wonderful medical and psychologic properties. So numerous and important are its medical applications, and so exhilarating and glorious its effect, according to the statements of the natives, that it is regarded as the vegetable incarnation of a deity, and the ceremonial eating of the plant has become the great religious rite of all the tribes of the southern plains. * * * * * * * * *

[1] The Mescal Plant and Ceremony, by James Mooney. *Therapeutic Gazette*, January, 1896.

"As a matter of fact, there are several varieties, probably all of the same genus, used by the Indians in a ceremonial way. The explorer Lumholtz mentions three varieties among the Tarahumari of northern Mexico, (see his article in *Scribner's Magazine* for October, 1894). A different sort, from the lower Rio Grande, is used by the Kiowas and associated tribes, and a smaller variety is found among the Mescalero Apaches of eastern New Mexico. In each language it has a different name, usually referring to the prickles. Among the Kiowas it was *señi*; among the Comanches, *wokowi*; with the Mescaleros, *ho*; and with the Tarahumaris, *hikori*. The traders of the Indian Territory commonly call it mescal, although it must not be confounded with another mescal in Arizona, the *Agave*, from which the Apaches prepare an intoxicating drink. The local Mexican name upon the Rio Grande is *peyote* or *pellote*, from the old Aztec name *peyotl*.

"The use of the plant for medical and religious purposes is probably as ancient as the Indian occupancy of the region over which it grows. There is evidence that the ceremonial rite was known to all the tribes from the Arkansas to the valley of Mexico, and from the Sierra Madre to the coast. The Mescalero Apaches take their name from it. Personal inquiry among the Navajos and Mokis proved that they had no knowledge of it.

"In proportion as the plant was held sacred by the Indians, so it was regarded by the early missionaries as the direct invention of the devil, and the eating of the peyote was made a crime equal in enormity to the eating of human flesh. From the beginning it has been condemned without investigation, and even under the present system severe penalties have been threatened and inflicted against Indians using it or having it in their possession. Notwithstanding this, practically all the men of the Southern Plains tribes eat it habitually in the ceremony, and find no difficulty in procuring all they can pay for. In spite of its universal use and the constant assertion of the Indians that the plant is a valuable medicine and the ceremony a beautiful religious rite, no agency physician, post surgeon,

missionary, or teacher—with a single exception—has ever tested the plant or witnessed the ceremony.

"A detailed account of mythology, history and sacred ritual in connection with the mescal would fill a volume. Such an account, to be published eventually by the Bureau of Ethnology, the writer is now preparing, as the result of several years of field study among the Southern Plains tribes.

"The ceremony occupies from twelve to fourteen hours, beginning about nine or ten o'clock and lasting sometimes until nearly noon the next day. Saturday night is now the time usually selected, in deference to the white man's idea of Sunday as a sacred day and a day of rest. The worshippers sit in a circle around the inside of the sacred tipi, with a fire blazing in the center. The exercises open with a prayer by the leader, who then hands each man four mescals, which he takes and eats in quick succession, first plucking out the small tufts of down from the center. In eating, the dry mescal is first chewed in the mouth, then rolled into a large pellet between the hands, and swallowed, the man rubbing his breast and the back of his neck at the same time to aid the descent. After the first round the leader takes the rattle, while his assistants take the drum, and together they sing the first song four times, with full voices, at the same time beating the drum and shaking the rattle with all the strength of their arms. The drum and rattle are then handed to the next couple, and so the song goes on round and round the circle—with only a break for the baptismal ceremony at midnight, and another for the daylight ceremony—until perhaps nine o'clock the next morning. Then the instruments are passed out of the tipi, the sacred foods are eaten, and the ceremony is at an end. At midnight a vessel of water is passed around, and each takes a drink and sprinkles a few drops upon his head. Up to this hour no one has moved from his position, sitting cross-legged upon the ground and with no support for his back, but now any one is at liberty to go out and walk about for a while and return again. Few, however, do this, as it is considered a sign of weakness. The sacred food at the close of the ceremony consists of parched corn in sweetened water; rice or other boiled grain; boiled fruit, usually now prunes or

dried apples; and dried meat pounded up with sugar. Every person takes a little of each, first taking a drink of water to clear his mouth.

"After midnight the leader passes the mescal around again, giving to each man as many as he may call for. On this second round I have frequently seen a man call for ten and eat them one after the other as rapidly as he could chew. They continue to eat at intervals until the close. There is much spitting, and probably but little of the juice is swallowed. Every one smokes hand-made cigarettes, the smoke being regarded as a sacred incense. At intervals some fervent devotee will break out into an earnest prayer, stretching his hands out toward the fire and the sacred mescal the while. For the rest of the time, when not singing the song and handling the drum or rattle with all his strength, he sits quietly with his blanket drawn about him and his eyes fixed upon the sacred mescal in the center, or perhaps with his eyes shut and apparently dozing. He must be instantly ready, however, when his turn comes at the song, or to make a prayer at the request of some one present, so that it is apparent that the senses are always on the alert and under control of the will.

"There is no preliminary preparation, such as by fasting or the sweat-bath, and supper is eaten as usual before going in. The dinner, which is given an hour or two after the ceremony, is always as elaborate a feast as the host can provide. The rest of the day is spent in gossiping, smoking, and singing the new songs, until it is time to return home. They go to bed at the usual time, and are generally up at the usual time the next morning. No salt is used in the food until the day after the ceremony.

"As a rule, only men take part in the regular ceremony, but sick women and children are brought in, and, after prayers for their recovery, are allowed to eat one or more mescals prepared for them by the priest."

It is to Mr. Mooney that we are indebted for the commencement of the scientific study of the drug in this country. On his return in the summer of 1894, from a prolonged residence among the tribes that use the drug, he brought with him a considerable

quantity of the dried "buttons" for use in scientific investigations. A portion of this material was turned over to Dr. H. W. Wiley, Chief of the Division of Chemistry of the Department of Agriculture, for a study of its chemical constituents. This task was assigned to the author by Dr. Wiley in September, 1894. The only literature of the subject at hand at that time was the article published by Dr. Lewin in 1888,[1] in which he announced the discovery and name, anhalonin, of an alkaloid in *Anhalonium Lewinii*, a name that had been given to the plant furnishing "mescal buttons" by Hennings, the botanist to whom Lewin intrusted the botanical identification of the crude material in which the alkaloid was found. Work had hardly been begun in the laboratory of the Department of Agriculture with the result of the separation of a considerable portion of Lewin's anhalonin, when Dr. Heffter[2] published an article in which he reported the results of a chemical study of four species of the genus Anhalonium: *A. fissuratum*, *A. prismaticum*, *A. Williamsii*, *A. Lewinii*. This was quickly followed by a report by Lewin of the continuation of his experiments mentioned above.[3]

For the aid of the American readers who may feel an interest in this subject, the writer has prepared the following table, in which the results of the investigations, hitherto reported, of the three more thoroughly studied species of anhalonium, are presented in a convenient form for reference and comparison:

[1] *Archiv für experimentelle Pathologie und Pharmakologie*, *1888*, 24, 401; *Therapeutic Gazette*, *1888*, p. 232, and in a pamphlet issued by Parke, Davis & Co., of Detroit, the same being a reprint from "The Pharmacology of the Newer Materia Medica."

[2] *Archiv für experimentelle Pathologie und Pharmakologie*, *1894*, 34, 65–86.

[3] *Archiv für experimentelle Pathologie and Pharmakologie*, 1894, 34, 374–391.

I. Table Showing the Chemical and Physical Properties of the Alkaloids from the Various Species of Anhalonium.

Species.	*A. fissuratum.*	*A. Williamsi.*	*A. Lewinii.*					
Investigators.	Heffter, 1894.	Heffter, 1894.	Heffter, 1894.			Lewin, 1888.	Lewin, 1894.	
Names of bases reported.	Anhalin.	Pellotin.	Alkaloid A.	Alkaloid B.	Alkaloid C.[1]	Anhalonin.	Crystalline anhalonin.[2]	Amorphous anhalonin.[2]
Formulas of bases analyzed.	$C_{10}H_{17}NO$.	$C_{13}H_{21}NO_3$.					$C_{12}H_{15}NO_3$.	
Crystalline form.	Crystals were obtained by adding NH_4OH to the concentrated water solution of the s'lp'te. White, opaque, adherent prisms, 2 mm. long, group'd in star forms.	Separates from alcohol in beautiful transparent tables that lie upon one another in cubical aggregates. It was crystallized from petroleum ether.	Sirupy, did not crystallize.	Sirupy, did not crystallize.	Sirupy, did not crystallize.	Sirupy, did not crystallize.	From aqueous solution, partly prismatic with irregularly pointed ends: partly tabular combinations; rhombic system. Crystals from ethereal solution gradually turn yellow.	Was not obtained in the crystalline state.
Solubility.	Cold water, very slight: more soluble in hot water: readily sol'ble in alcohol, methyl alcohol, ether, and petroleum ether.	Soluble in water by long boiling; soluble in alcohol, ether, acetone, chloroform, and petroleum ether.					Soluble in a large quantity of water; uncommonly easily soluble in alcohol, ether, chloroform, and benzene.	Same solubilities as the crystalline base.
Melting-point.	On platinum foil, melts to a clear, bright-yellow liquid, which gives off vapors having no characteristic odor; in a tube it melts quietly without decomposition at 115°, and crystallizes on cooling.	On platinum foil, melts to a bright-yellow liquid, with the formation of vapors having the odor of volatile amine bases: in a tube melts at 110°.					Softens at 74° and is liquid at 77.5°. It can be sublimed without decomposition.	

[1] Contained in the uncrystallizable mother-liquor remaining after the crystallization of the sulphates of alkaloid A and B.

[2] Prepared by E. Merck & Co.

Taste.	Aqueous solutions of the salts of this base have a bitter, saline taste, resembling that of potassium iodid.	Intensely and persistently bitter.						
Reactions with alkaloidal precipitants								
KI + HgI_2.	Amorphous precipitate.	Amorphous precipitate, becoming short, thick prisms.	Snow-white, well-formed microscopic tables.	Citron-yellow, crystalline precipitate, composed of short needles grouped in clusters.				
KI + BiI_3.	Amorphous precipitate.	Amorphous precipitate, becoming orange red, curved needles.	Amorphous precipitate.	Amorphous red-brown precipitate.				
KI + CdI_2.		Amorphous precipitate, becoming colorless, right-angled tables that lie upon each other in such a maner as to form peculiar dendritic figures.	No precipitate.	No precipitate.	A precipitate is formed.			
KI + I_2.	Brown drops separate, which solidify to prisms after a time.	Amorphous precipitate, becoming bright-brown, long, thin needles.	Very thin, long needles of a beautiful steel-blue color.	Amorphrus, fire-red precipitate.		Amorphous, brown-red precipitate.	Very small brown needles	
Phosphotungstic acid.	Amorphous precipitate.	Amorphous precipitate.	Amorphous precipitate.	Amorphous, yellow-white precipitate.		Crystalline, white precipitate.	Amorphous, white precipitate.	Amorphous, white precipitate.

Phosphomolybdic acid.	Amorphous precipitate.	Amorphous precipitate.	Amorphous precipitate.				Amorphous, yellow precipitate.	Amorphous, yellow precipitate.
$PtCl_4$.	No precipitate in aqueous solution; a precipitate separates in the form of drops from the alcoholic solution.	From weak alcoholic solution, forms golden yellow, fern-like aggregates of crystals.	Bright-yellow, fine needles,, grouped in the form of sheaves. This precipitate is very insoluble in water.	Short, broad, obliquely cut prisms.		Flaky crystals after shaking.	Bright-yellow precipitate, which arranges itself in clusters of crystals.	Amorphous, yellow-brown precipitate.
$AuCl_3$.	The same as with $PtCl_4$.	No precipitate. (?)	No precipitate.	No precipitate.	Precipitate.	Crystalline, brown-red precipitate.	Yellow-brown, beautifully-formed crystals.	Amorphous, brown precipitate.
$HgCl_2$.	The same as with $PtCl_4$.							Amorphons, white precipitate.
Picric acid.		Amorphous precipitate, becoming star-formed groups of prismatic needles.	No precipitate.	No precipitate.	Precipitate.	Yellow, crystalline precipitate.	Bright-yellow, amorphous precipitate that becomes crystalline on standing.	Bright-yellow, amorphous precipitate.
Tannic acid.		No precipitate.	No precipitate.	No precipitate.		Yellowish-white, amorphous precipitate.	White, amorphous precipitate.	
$AgNO_3$.							White, amorphous precipitate in solutions of the free base.	
$K_2Cr_2O_7$.							In concentrated solution dendritic crystals are formed after some time.	Amorphous, brown-red precipitate.

$FeCl_3$.							Immediately after the addition of the reagent there is formed a thick mass of yellow-white, long prismatic crystals.	No precipitate.
NH_4CNS.							No precipitate.	Amorphous, brown precipitate.
Color reactions.								Similar to anhalonin.
H_2SO_4.	Quickly dissolves with no color in the cold or on heating.	Dissolves with a slight yellow color that is not altered by standing or warming.					Is colored yellow and on heating turns to a violet-red color that is very persistent.	
HCl.	The same as with H_2SO_4.							
$H_2SO_4 + HNO_3$.	A drop of HNO_3 added to the H_2SO_4 solution produces a green color.	The crystal dissolves with a brown-red color that changes to an intense permanganate color on warming.	The same as with pellotin.	The same as with pellotin.		A permanganate color which turns yellow after some time.	A deep violet-red which soon becomes br'wn and finally colorless.	
HNO_3.		The same as with $H_2SO_4 + HNO_3$.	The same as with $H_2SO_4 + HNO_3$.				A light-red, then blood-red, which turns yellow on warming.	

HNO_3 followed by KOH	A small crystal warmed on the water-bath with one to two drops of HNO_3 forms a yellow solution that is turned a persistent orange-red by an excess of solution of KOH.							
Cl_2.							Chlorin water turns an aqueous solution light yellow; on warming this becomes rose-red and changes to green on long standing.	
SALTS.					No crystallizable salt was obtained.			
Hydrochlorate.	$C_{10}H_{17}NOHCl$.							
Crystalline form.	On adding ether to the solution of the salt in absolute alcohol, small, shining, tabular crystals were obtained.	Hard prisms					This salt crystallizes from the aqueous solution more readily than the free base. It forms colorless, six-sid'd prisms of the rhombic system, 0.3–0.7 mm. broad and 5–7 mm. long. Their terminations are sometimes pointed and sometimes basal planes.	A brown, very hygroscopic amorphous powder.

Solubility.	Very readily soluble in water, alcohol, and methyl alcohol.	Very easily soluble in water.						Slightly soluble in cold water; easily soluble in hot water, forming a neutral solution: soluble in alcohol.	
Melting-point								Melts at 254–255° with decomposition.	
Specific rotatory power.								$[\alpha]_D^{25} = -40.56$ Concentration was 1.333 g'm's in 100 cc. of 50 per cent. alcohol.	
Taste.								Slightly bitter.	Very bitter.
Sulphate.	$(C_{10}H_{17}NO)_2 . H_2SO_4 + 2H_2O$.								
Crystalline form.	Colorless, shining, very thin tables were obtained by crystallization from alcohol.	Not obtained in crystalline form.	Colorless, shining needles.	Small, white, non-lustrous, rhombic tables.					
Solubility.	Very easily soluble in cold water; less readily sol'ble in cold alcohol but readily soluble in hot, ninety per cent alcohol.		Difficultly soluble in cold water, easily soluble in hot water; almost insoluble in alcohol.	More readily soluble in cold water than alkaloid "A."					

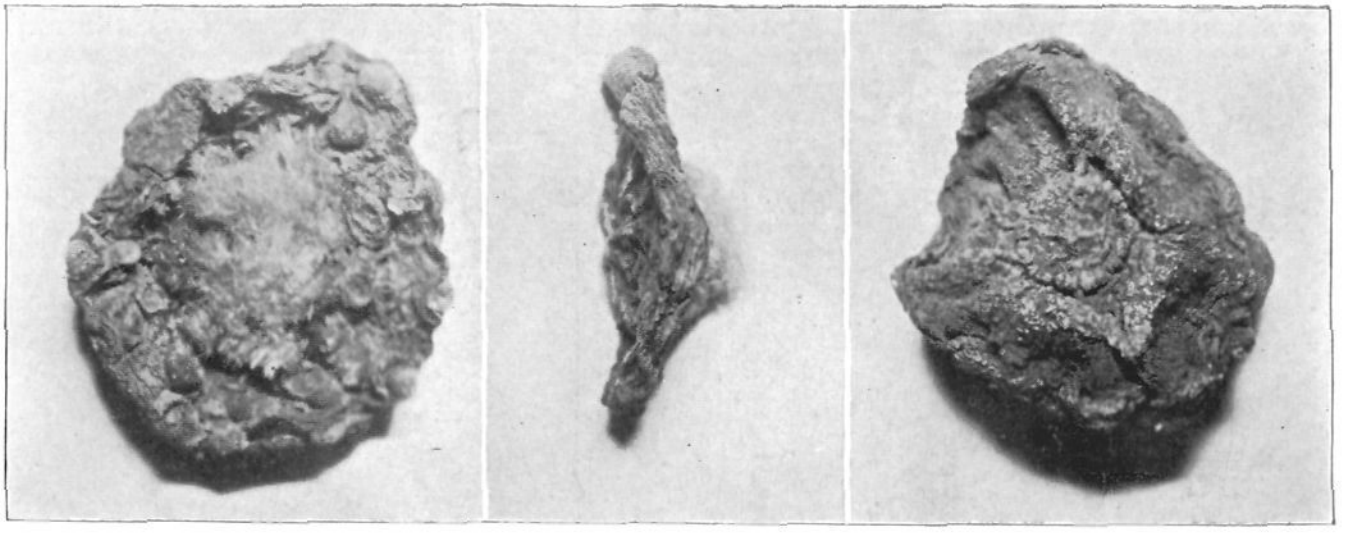
Melting-point	Melts without coloration at 197°.		169°.	220°.					
Oxalate.	$(C_{10}H_{17}NO)_2(COOH)_2$.								
Crystalline form.	Readily crystallized from hot alcohol in a form similar to that of the sniphate.	Needles.							
Solubility.	Similar to anhalin sulphate.	Very easily soluble in cold water; insoluble in alcohol.							

All of the bases mentioned in the above table are possessed of marked physiological properties, and produce death when administered to the lower animals in sufficient doses. The nature and extent of the physiological activity of these alkaloids as determined by the experiments of Lewin and Heffter, are shown in the following table :

II. TABLE SHOWING THE NATURE AND INTENSITY OF THE PHYSIOLOGICAL PROPERTIES OF THE ALKALOIDS FOUND IN VARIOUS SPECIES OF ANHALONIUM.

Species.	*A. fissuratum.*	*A. Williamsii.*	*A. Lewinii.*					
vestigator.	Heffter, 1894.	Heffter, 1894.	Heffter, 1894.			Lewin, 1888.	Lewin, 1894.	
Names of bases reported	Anhalin.	Pellotin.	Alkaloid A.	Alkaloid B.	Alkaloid C.	Anhalonin.	Crystalline anhalonin hydrochlorate.	Amorphous anhalonin hydrochlorate.
Minimum observed active doses.	A cat was given 0.107 gram per kilo of the body weight of anhalin sulphate by hypodemic injection. After a violent attack of vomiting the animal recovered in forty-five minutes. 0.1 gram was without action when taken by way of the mouth by the investigator himself.	For a rabbit, 0.07 gram per kilo; for a cat 0.05 gram per kilo, the alkaloid being dissolved in acidulated water and administered hypodermically. A slight effect is felt by men after taking 0.05 – 0.06 gram by way of the mouth.	No experiments with warm-blooded animals are reported with the alkaloids. The experiments with frogs were rather limited in consequence of an insufficient supply of material. 0.02 gram of the sulphate by hypodermic injection was necessary to obtain pronounced symptoms in the case of a frog, (*Rana temporaria.*)	As small a hypodermic dose as 0.005 gram of the sulphate was active in the case of a frog.	0.005 gram of the „brown, sirupy mother liquor was sufficient to cause "reflex tetanus" when administered hypodermically to a frog.	Several tests with animals were reported, but they were mostly made with preparations that were likely to contain more than one of the alkaloids.	0.01 gram was found to be active, and 0.02–0.04 gram poisonous in the case of rabbits, but the weights of the animals were not reported.	The poisonous dose for frogs was 0.002 to 0.004 gram; for rabbits, 0.005 gram, 0.01 causing marked tetanus.
Lethal dose, grams per kilo of body weight	0.05 gram of the sulphate given hypodermically killed a medium-sized frog (*Rana temporaria*) in twenty minutes. The weight of the animal was not stated.	For rabbits, 0.10 of the free base, dissolved in acidulated water and administered hypodermically.					For rabbits, 0.16 – 0.20 administered hypodermically.	For rabbits, 0.06-0.10 administered hypodemically.

The nature of the action.	The action of this alkaloid upon frogs is summed up as a paralysis of the central nervous system without preceding excitement, the action apparently being limited to the brain.	0.05–0.06 gram has a narcotic effect when taken by men. This is evidenced by a feeling of weariness that comes on two hours after taking the drug into the stomach. There is also a heaviness of the eyelids, disinclination to physical and mental exertion, and a lowering of the pulse rate. These symptoms all disappeared after one-half to one hour. In the case of rabbits, large doses produce muscular weakness, followed by tetanic spasm, with opisthotonus, increasing in intensity or followed by recovery according to the amount of the dose. There is increase of reflex excitability and the tetanic spasm can be produced by exterior disturbance. With frogs the tetanic condition may last three or four days.	No increase of reflex excitability was observed.	No increase of reflex excitability was observed.	More active than either "Alkaloid A," "Alkaloid B," or pellotin. Tetanic spasms with increased reflex excitability.		Tremors, tetanic spasms with opisthotonus, marked increase of reflex excitability. In the case of frogs, the animal remains for several days in such a condition that any slight exterior disturbance calls forth a series of tetanic convulsions.	Tetanic spasms, with increase of reflex excitability, the latter apparently being less marked than in the case of the crystalline anhalonin hydrochlorate.



Top. Edge. Under side.

Fig. 1. "Mescal buttons."

To follow page 640).

Fig. 2. *Anhalonium Lewinii.*

Fig. 3. *Anhalonium Williamsii.*

Fig. 4. Anhalonium fissuratum.

Fig. 5. Anhalonium prismaticum.

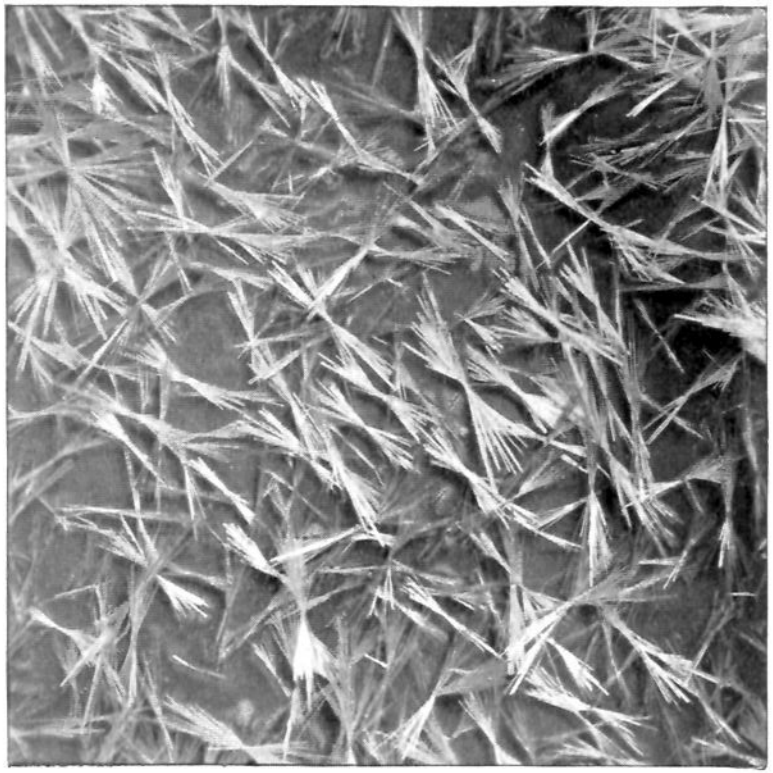


Fig. 6. Anhalonin hydrochlorate.

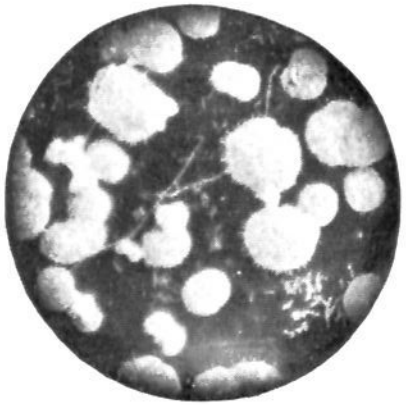


Fig. 7. Hydrochlorate of a new alkaloid separated from *Anhalonium Lewinii*.
(Enlarged nine diameters.)

The materials used by Lewin in his experiments reported in 1894 were prepared in the laboratory of E. Merck & Co., of Darmstadt. In their report to Lewin, mention was made of the presence of still a third base in the drug, which forms a crystallizable hydrochlorate that is easily soluble in cold water. It seems quite possible that the substance described under the name of "amorphous anhalonin hydrochlorate" was a mixture of alkaloidal hydrochlorates.

Heffter also made a cursory examination of a small sample of *Anhalonium prismaticum* and found it to contain a small percentage of alkaloidal constituents possessing high physiological activity.

In the article published by Lewin, in 1894, and cited above, mention is made of a partial analysis of a sample of *Anhalonium Jourdanianum* made in 1889 with the result of the separation of an alkaloid that formed a crystalline hydrochlorate and resembled anhalonin in its characteristic color-reaction as well as the nature of its physiological action upon frogs. In the same article report is also made of an examination of *Anhalonium Williamsii*, several species of Mammillaria, and one species of *Opuntia*. The study of *A. Williamsii*, which was made in 1891, resulted in the separation of an alkaloid that caused an increase of reflex excitability, and marked tetanus when administered to frogs. The tendency of the tetanic condition to continue for several days was very pronounced. The milky juices yielded by *Mamillaria polythele*, *M. centricirrha* var. *pachythele*, *M. pulchra*, *Haw. and M. arietina*, were found to possess no poisonous properties. *Mammillaria uberiformis* was found to be poisonous. *Rhipsalis conferta*, a member of the *Opuntia* group, yielded a slimy juice that was difficultly soluble in water. When this was administered to frogs by hypodermic injection a paralysis of the voluntary muscles was produced, which was followed by heart failure.

It is very apparent from the results of the investigations which I have thus briefly summarized, that the *Cactaceae* is a group of plants worthy the attention of the botanist, the chemist, the pharmacologist, the physician, and the toxicologist, as well as the attention of the entire mass of nature-loving human-

ity. It is to be hoped that American scientists will not leave the task of exploring this promising field entirely to workers beyond the sea, considering our proximity to much of the necessary material.

It is the purpose of the present article to bring the subject to the attention of American investigators and to briefly outline the work that has been done in the laboratory of the U. S. Department of Agriculture. "Mescal buttons," the dried, commercial form of *Anhalonium Lewinii*, have served as the starting point for all our investigations. Fig. 1 shows the appearance of the "buttons" when viewed upon the top, upon the edge, and upon the under side.

Figs. 2, 3, 4, and 5, show the appearance of living specimens of *Anhalonium Lewinii*, *A. Williamsii*, *A. fissuratum*, and *A. prismaticum*, respectively, the illustrations being prepared from photographs made by the author from plants growing in the National Botanical Gardens.

An alkaloid corresponding in its properties to Lewin's anhalonin has been prepared in a considerable amount and in a high state of purity. Fig. 6 shows the appearance of the bottom of a crystallizing dish in which the hydrochlorate was crystallized from alcohol by spontaneous evaporation over sulphuric acid in a vacuum.

A second and, very recently, a third alkaloid have been separated from the drug. All three of these alkaloidal preparations have been subjected to physiological tests by Drs. Prentiss and Morgan, and the results of their investigations will soon be published in the *Medical Record*. They have recently published two articles upon the physiological action and therapeutic value of the crude drug in the *Therapeutic Gazette*.[1] As for the third alkaloid separated, let it suffice to say for the present that it has been found to be much stronger than any alkaloid hitherto separated from any member of the genus Anhalonium, as 0.02—0.025 gram of its hydrochlorate per kilo or body weight is fatal to rabbits, and 0.03 gram per kilo of body weight suffices to kill a full grown guinea-pig. The hydrochlorate of this alkaloid crystallizes in nodular groups of radiating needles. Fig. 7 was made

[1] Sept., *1895*, and Jan., *1896*.

from a photograph of crystals obtained by the spontaneous evaporation of a solution of the alkaloidal salt in ninety per cent. alcohol.

An examination of the resinous constituents of the plant is in progress, as well as a study of those of its constituents that are of interest to the vegetable physiologist rather than to the therapeutist.

A more extended report of this work is reserved for a future paper. Before closing this preliminary announcement, however, I wish to express my indebtedness to Dr. Wiley for much greatly appreciated assistance in the work, and to Dr. Brown for the aid that he very kindly rendered me in the preparation of the photographs used for the illustration of the article. I also desire to express my appreciation of the patience with which both Dr. Wiley and the gentlemen of the Bureau of Ethnology have awaited the progress of this work, which has been largely limited to spare moments not required by other duties.

WASHINGTON, D. C., May 11, 1896.

THE SULPHURIC ACID PROCESS OF REFINING LIXIVIATION SULPHIDES.[1]

BY FREDERIC P. DEWEY.

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THE time is fast approaching when more chemistry must be used in the extraction of the precious metals in the United States. The chief objections to chemical methods are the technical skill required in the management, the higher grade of labor necessary and the time required to turn out product, thus locking up large amounts of capital; but these difficulties are becoming less applicable all the time. Then too, the wonderful success attained in this country in extracting the precious metals by smelting with lead has retarded the application of chemical methods.

The chemical process of extracting silver by lixiviating, or leaching its ores with solution of hyposulphite of sodium, was introduced by von Patera in 1858, and has been variously improved, notably by the substitution of the calcium salt for

[1] Read before the Washington Section of the American Chemical Society, March 12, 1896.