rather it would be left behind as a mat or amorphous material on the cell walls. The xylem of a tree at 100 m of height would contain about 10 percent of this gel and would be more readily studied. This calculation is only a first approximation. It is likely that the freedom of motion of the segments is overestimated, which causes the weight percent to be underestimated. Neglect of the low-frequency lattice vibrations of the chains and of the lower-frequency vibrations within the individual segments causes the weight percent to be overestimated.

The gel structure which we propose may be a residue of the last stages of cellulose microfibril synthesis, at the cell walls, and a characteristic of fully differentiated tracheid or vessel cells in the xylem. It is not clear at this time whether the fibril synthesis in such cells occurs at the ends of fibrils, with individual glucose residues being attached to the ends, or whether it occurs by formation of chains that extend out into the solution and then condense into fibrils bonded together by hydrogen bonding and dispersion forces.

It is attractive to think in accord with our hypothesis that the growth is by chains and that the ends are left dangling in the fully differentiated tracheid cells when growth stops. There is some evidence that this may be the case. A number of electron microscopy studies have shown that there are amorphous residues—slimelike or matlike desposits on the cell walls (*4*). These can be eliminated by thoroughly washing the cells before examination.

A second bit of evidence for the existence of the gel is available. The gel-like structure would be expected to be very fragile and to break off after prolonged functioning of the tracheid conduits, much as straw breaks off and is carried downstream when a wheat field is flooded. It is found that in mature tracheids there are encrustations on the tori (*5*), which may result from the gradual erosion of a very delicate structure.

The hypothesis that a gel structure supports the water columns in the xylem is in accord with the existing experimental facts and is an attractive alternative to the hydrostatic tension hypothesis. Studies of the activity of water in the xylem and measurements of the concentration of gel in the xylem will determine if it is to be preferred.

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6 March 1972

Peyote Alkaloids: Identification in the Mexican Cactus Pelecyphora aselliformis Ehrenberg

Abstract. *Hordenine, anhalidine, pellotine, 3-demethyltrichocereine, mescaline, 3,4-dimethoxy-β-phenethylamine, and the* N*-monomethyl derivatives of mescaline and 3,4-dimethoxy-β-phenethylamine have been isolated or identified, or both, in alkaloid extracts of a Mexican "peyote" cactus,* Pelecyphora aselliformis *Ehrenberg. This is the first report of the occurrence of some of these alkaloids, including mescaline, in a North American cactus other than* Lophophora.

Lophophora williamsii (Lemaire) Coulter, the peyote cactus, contains many alkaloids including mescaline (3,4,5 - trimethoxy - β - phenethylamine) and has a history of use by the Indians of North America as a medicine and a hallucinogen (*1*, *2*). Many other North American cacti have also been recorded as primitive medicines in anthropological and ethnobotanical reports (*3*, *4*). Of particular interest to us are several cactus species that are also called "peyote" by the Indians and have reputed uses as stimulants, inebriants, narcotics, or hallucinogens. Schultes has repeatedly suggested that these additional "peyote" cacti be examined phytochemically (*5*). In our previous work we have followed these leads, and our investigations have resulted in the identification of several new and several previously known cactus alkaloids (*6*).

Pelecyphora aselliformis Ehrenberg, from the state of San Luis Potosí, Mexico (*7*), is one of these "peyote" cacti. Its oddly flattened tubercles (see Fig. 1) have given rise to the common name "hatchet cactus"; the additional common names of "peyote" and "peyotillo" (little "peyote") may refer to some slight morphological similarity to *Lophophora* or perhaps to similar physiological effects (*8*). Several authors have referred to its sale and use as a drug among the Mexican Indians (*4*, *5*, *8*–*10*). Reko (*10*) has reported that the plant appears to contain toxic alkaloids, and recently, as our current investigation was being concluded, Agurell *et al.* (*11*) reported the identification of anhalidine (2-methyl-6,7-dimethoxy-8-hydroxy-1,2,3,4-tetrahydroisoquinoline) and hordenine (*N*,*N*-dimethyltyramine) and the detection of additional unknown alkaloids in the plant. In this report we present the results of further analyses of the alkaloid content of the plant in an attempt to explain its reputed physiological activity.

Approximately 300 fresh *P. aselliformis* (*12*) were sliced, dried (62 percent moisture), and pulverized in a Wiley mill to yield 5.5 kg of powdered material which was de-fatted with petroleum ether in large Soxhlet extractors. The de-fatted plant material was made alkaline and extracted by means of chloroformic percolation, and the extract was purified and resolved into phenolic and nonphenolic portions as previously described (*13*, *14*).

The nonphenolic extract was applied to four 1-mm plates of silica gel preparative F_{254} for preparative thin-layer chromatography (TLC) (*15*) and developed in a mixture of chloroform, ethanol, and concentrated ammonium hydroxide (15:20:1). Two of the nine bands observed under short-wavelength ultraviolet light, after removal, elution, and analytical TLC, showed components giving R_F values and color reactions (*14*) similar to those of mescaline and some of its analogs. The analytical TLC was carried out on 0.25-mm silica gel G plates in mixtures of either ethyl acetate, methanol, and ammonium hydroxide (17:2:1); chloroform, methanol, and concentrated ammonium hydroxide (80:20:1); or chloroform, acetone, and concentrated ammonium hydroxide (10:8:1). We could find no TLC system capable of separating mescaline from 3,4-dimethoxy-

Table 1. Mass spectral data for dansylated nonphenolic β-phenethylamines.

Dansyl derivative of	Molecular ion	*m/e* (relative height)*
β-Phenethylamine	354.1400	354 (43%), 263 (9%), 91 (14%)†
N-Methyl-β-phenethylamine	368.1557	368 (54%), 277 (23%), 91 (11%)†
4-Methoxy-β-phenethylamine	384.1506	384 (65%), 263 (18%), 121 (65%)†, 91 (8%)
N-Methyl-4-methoxy-β-phenethylamine	398.1663	398 (5%), 277 (31%), 121 (26%)†, 91 (5%)
3,4-Dimethoxy-β-phenethylamine	414.1621	414 (19%), 263 (21%), 151 (76%)†, 91 (26%)
N-Methyl-3,4-dimethoxy-β-phenethylamine	428.1768	428 (10%), 277 (26%), 151 (24%)†, 91 (3%)
Mescaline	444.1726	444 (7%), 263 (21%), 181 (75%)†, 91 (19%)
N-Methylmescaline	458.1874	458 (9%), 277 (28%), 181 (24%)†, 91 (2%)

* The base peak (from the dansyl portion) was always 170; relative heights are given in comparison to this peak; additional ions derived from the dansyl group, that is, 234 or 235, 186, 168, 154, 127, and 115, are not listed. † Product from β-cleavage [see Reisch *et al.* (*19*)].

β-phenethylamine or *N*-methylmescaline from *N*-methyl-3,4-dimethoxy-β-phenethylamine. However, these compounds were separable by gas-liquid chromatography (GLC) (*16*), and the coinjection of reference alkaloids with the respective alkaloids in the nonphenolic extracts gave enhanced peak heights.

To further verify the presence of the small quantities (approximately 1 to 3 mg total) of these four alkaloids, we turned to mass spectrometry of their chromatographically separable dansyl (5-dimethylamino-1-naphthalenesulfonyl) derivatives. Dansyl-conjugate formation combined with mass-spectral identification has been used with wide success in the determination of amines and amino acids in complex biological extracts (*17–19*). Our dansylated materials (*17–19*) were applied in a single spot near the corner of a 1-mm silica gel G plate and developed two-dimensionally, first in a mixture of chloroform and butyl acetate (10:1) and second in a mixture of benzene and triethylamine (10:1). This two-dimensional TLC system was adequate to separate, on a single plate, sufficient quantities for mass spectral analyses of the dansyl derivatives of the following eight β-phenethylamines: β-phenethylamine, 4-methoxy-β-phenethylamine, 3,4-dimethoxy-β-phenethylamine, mescaline, and the *N*-monomethylated analogs of these compounds. We located the positions of the dansylated compounds on the plates by means of their brilliant yellow fluorescence under long-wavelength ultraviolet light, eluted the compounds with ethyl acetate, and applied suitable volumes to the probe of the mass spectrometer (*20*) (Table 1). Eluates of the appropriate spots from our dansylated nonphenolic extract gave observed mass-to-charge ratios (*m/e*) and fragmentations consistent with our previous GLC and TLC identifications of 3,4-dimethoxy-β-phenethylamine (414), *N*-methyl-3,4-dimethoxy-β-phenethylamine (428), mescaline (444), and *N*-methylmescaline (458).

Analytical TLC of the phenolic alkaloid portion revealed an alkaloid pattern quite similar to that of the phenolic extracts of *L. williamsii* (*14*). Tetrazotized benzidine spray, which gives different colored chromophores with variously substituted phenolic alkaloids, aided in the identification of the four major components as hordenine (yellow), pellotine (1,2-dimethyl-6,7-dimethoxy-8-hydroxy-1,2,3,4-tetrahydroisoquinoline) (red), anhalidine (red fading to green), and an unknown alkaloid (orange). Cochromatography of the phenolic alkaloids with reference peyote alkaloids and similar R_F values in the several chromatographic systems with reference peyote alkaloids substantiated the identification of the first three compounds.

Employing preparative TLC, as described above, we were able to resolve the phenolic alkaloids on eight plates into two major portions: anhalidine-pellotine and unknown-hordenine. Repeated additional developments of these portions with approximately 30 preparative plates and solvents consisting of mixtures of either chloroform, ethanol, and concentrated ammonium hydroxide (15:20:1); chloroform, methanol, and concentrated ammonium hydroxide (18:1:1); or chloroform, acetone, and diethylamine (5:4:1) gave chromatographically pure fractions of anhalidine, pellotine, hordenine, and the unknown alkaloid. The crystalline hydrochlorides were successfully prepared (*12*) for hordenine [yield, 34.7 mg; (0.00063 percent); melting point and mixed melting point, 181° to 182°C], anhalidine [yield, 3.7 mg (0.000067 percent); melting point and mixed melting point, 244° to 245°C], and pellotine [yield, 0.52 mg (0.0000094 percent); melting point 242° to 245°C; mixed melting point, 244° to 247°C with racemic pellotine (melting point, 250° to 251°C)]. Infrared spectra (KBr pellets) of the isolated and authentic hydrochlorides of hordenine and anhalidine were indistinguishable. Since the amount of pellotine hydrochloride obtained was insufficient for good infrared analysis, it was subjected to mass spectrometry, where it gave nearly the same *m/e* (237.134 versus 237.136) and fragmentation (base peak 222, corresponding to loss of a methyl group) as syntheric racemic pellotine hydrochloride.

Our attempts to crystallize the un-

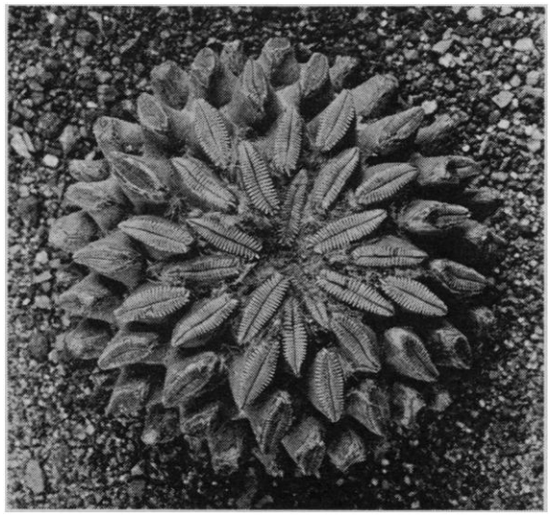

Fig. 1. Top view of a small Mexican cactus, *Pelecyphora aselliformis* Ehrenberg (× 0.9). Traces of peyote alkaloids, including the hallucinogen mescaline, have been identified in the plant.

known phenolic alkaloid as the hydrochloride were unsuccessful, so we obtained nuclear magnetic resonance (NMR) spectra with the free base (*21*). Mass spectrometry revealed a large molecular ion peak at *m/e* 225.136 ($C_{12}H_{19}O_3N$) and fragmentation (substituted tropylium ion at *m/e* 167.072) consistent with a proposal from the NMR data that the unknown was *N,N*-dimethyl-3-hydroxy-4,5-dimethoxy-β-phenethylamine (3-demethyltrichocereine). This compound was synthesized (*22*) and crystallized as the oxalate. The melting point and mixed melting point of the isolated [yield, 10.0 mg (0.000018 percent)] and synthetic oxalates were identical (155° to 156°C), and the NMR spectra of the synthetic base were essentially the same as those of the isolated base.

Lundstrom has recently detected 3-demethyltrichocereine in extracts of *L. williamsii* (*2*), and, with the exception of *N*-methyl-3,4-dimethoxy-β-phenethylamine, all of the eight alkaloids we have identified in *P. aselliformis* have been previously detected in *L. williamsii*. This is the first report of the presence of mescaline in any North American cactus species other than peyote, although mescaline has been found in several South American cacti (*11*). The presence of these alkaloids would seem to verify the reported native uses of the plant as a drug. However, the fact that the content of mescaline detected in *P. aselliformis* is so small (< 0.00002 percent versus > 1 percent in dried peyote) (*1*) casts doubt on this speculation (*23*). Peyote alkaloids are definitely present in this cactus, but it is questionable whether these alkaloids are present in concentrations sufficient to cause physiological effects upon ingestion.

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22. We thank Drs. S. Teitel and A. Brossi of Hoffmann–La Roche, Inc., for synthesizing this compound.
23. Extraction of freshly uprooted *P. aselliformis* yielded similarly small quantities of the alkaloids, thus discounting the possibility that a depressed physiological condition of the original plants might have caused a lower alkaloid content. The possibilities still exist that geographical, seasonal, and strain variations might affect the amount of alkaloid accumulated.

24. This work was supported in part by grants MH-17128-03 and MH-21448-01 from the National Institute of Mental Health.

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8 March 1972

Ethanol Oxidation: Effect on the Redox State of Brain in Mouse

Abstract. *Administration of a single large dose of ethanol to mice results in increases, for concentrations in the brain, of ratios of lactate to pyruvate, of α-glycerophosphate to dihydroxyacetone phosphate, of malate to oxaloacetate, and of glutamate to the product of α-ketoglutarate and ammonium ion. These changes are noticed as early as 5 minutes after the single dose is given. Ethanol administration for 30 days also produces these changes in metabolite concentrations in the brain. However, in contrast to the single alcohol dose, long-term alcohol administration results in a marked decrease in the concentration of adenosine triphosphate in brain and increases in those of adenosine diphosphate and adenosine monophosphate. Pyrazole, an inhibitor of alcohol dehydrogenase, prevents the effects of ethanol on the concentration of brain metabolites. These results may provide new insight into the biochemical and pharmacological effects of alcohol on brain metabolism and the importance of alcohol dehydrogenase activity in the brain.*

The dominant role of the liver in the metabolism of ethanol is documented (*1*). However, by the use of sensitive techniques (*2*) it has been demonstrated (*3*) that the brain also oxidizes small amounts of ethanol. Alcohol dehydrogenase from brain has been isolated and its kinetics studied (*3*). In liver, when ethanol is being metabolized the "redox state" is shifted toward greater reduction. Oxidation of ethanol in liver, catalyzed by alcohol dehydrogenase, results in an increased ratio of reduced nicotinamide adenine dinucleotide (NADH) to the oxidized form (NAD). The value of this ratio at the site of oxidoreductions is important because it bears on the metabolism of oxidizable and reducible substrates. We investigated the effect of ethanol oxidation on the redox state of brain as a means of understanding the most dramatic biochemical and pharmacological actions of ethanol on the central nervous system.

In the study reported here, the effects of a single large dose of ethanol and of long-term ethanol administration on the concentrations of certain dehydrogenase-linked redox pairs has been investigated. Albino Swiss mice (25 to 28 g) were used. In experiments where the effects of a single alcohol dose was studied, mice were divided into two groups. One group received ethanol (3 g/kg, intraperitoneally) as a 25 percent solution in water, and the other group received equal