studied by Hays and Opdyke, the two reversed events in the Gauss normal epoch are resolved on only one of the cores (Eltanin 13, core 3), and this same core also shows a clearly defined normal event with an interpolated age between the Gilsá event and the Gauss-Matuyama boundary of 1.99 million years ago, in agreement with the radiometric age of the Olduvai event.
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35. R. Hide, *Science* **157**, 55 (1967); E. Irving [*J. Geophys. Res.* **71**, 6025 (1966)] has also suggested that reversals may be due to shifts in the earth's axis of rotation.
36. The profiles used are from the South Pacific (EL20, EL19, S16, S18, MN5, S15) (see *11*), the Indian Ocean (V16) (see *11*), and the Juan de Fuca Ridge (see *20*).
37. A. Cox, R. R. Doell, G. B. Dalrymple, *Geol. Soc. London Quart. J.*, in press.
38. I am indebted to R. R. Doell and George Thompson for reviewing the manuscript of this article, and to F. J. Vine for supplying his interpretation of the Eltanin 19 profile prior to publication.

Hallucinogens of Plant Origin

Interdisciplinary studies of plants sacred in primitive cultures yield results of academic and practical interest.

Richard Evans Schultes

An outstanding mark of this century will certainly be the growth in use, abuse, and misuse, in sophisticated cultures, of hallucinogenic substances of vegetal and synthetic origin (*1*).

Primitive cultures, where sickness and death are usually ascribed to a supernatural cause, have long accorded psychoactive plants a high, even sacred, rank in their magic, medical, and religious practices, because their ethnopharmacology often values the psychic effects of "medicine" more than the physiological. Ethnobotanical studies have recently advanced our understanding of known hallucinogenic plants and have uncovered new ones, some of which have yielded compounds (Fig. 1) of extraordinary chemical and pharmacological interest, even of promise in modern medicine (*1–5*).

The pace of research into hallucinogens in dying or disappearing primitive cultures; the success of studies into the plants and their constituents; and the confusion generated by casual or frivolous interests in some segments of our society—all seem to justify an ethnobotanical summary based upon the premise that, even though only an interdisciplinary consideration can adequately cope with this fast-growing field, the starting point for understanding naturally occurring psychoactive substances must be an appreciation of the identification and aboriginal significance of the plants involved. My own ethnobotanical research which, since 1936, has taken me into remote areas of the New World to study native narcotics, has convinced me that there exists an appreciable number of hallucinogenic plants still unknown to science, and that we can no longer afford to ignore reports of aboriginal uses merely because they fall beyond the limits of our credence. Primitive cultures are fast disappearing and, with them, native knowledge of plant properties that could help us along paths of academic and practical achievement.

In view of the number of plant species, variously estimated at from 400,000 to 800,000, those that have been used as hallucinogens are few; probably no more than 60 species of cryptogams and phanerogams. Only 20 may be considered important. Even more interesting is the unexplained concentration of the majority of the hallucinogens in the New World. In both hemispheres, there are plants with hallucinogenic properties which apparently have never been employed as narcotics, but even if these were added to those that man has bent to his purpose, the number is very small. Since most hallucinogens owe their activity to alkaloids and at least 5000 higher plants are alkaloidal, the small number of hallucinogens is even more astounding. Glycosides, resinoids, essential oils, and other organic constituents may also be responsible, so the limited number of hallucinogens must be considered challengingly provocative (*6*).

Hallucinogens occur nearly throughout the plant kingdom. Although most are spermatophytes, some of the biologically, chemically, and sociologically most fascinating are cryptogams.

Agaricaceae

The presence of toxic constituents in so many basidiomycetes led to the early discovery of hallucinogenic properties in the mushrooms. It has even been postulated that mushrooms were anciently and widely valued in primitive religions; that the very concept of deity arose from their effects; and that their present disjunct ritualistic use is relict.

The hallucinogenic use of the fly agaric (*Amanita muscaria*) by primitive tribesmen in Siberia came to the attention of Europeans in the 18th century. This fungus—widespread in north-temperate parts of both hemispheres—has long been recognized as toxic; its name refers to the European custom of employing it to poison flies. In recent times, its use as an inebriant has been known in only two centers: extreme western Siberia, among Finno-Ugrian peoples, the Ostyak and Vogul; and extreme northeastern Siberia, among the Chukchi, Koryak, and Kamchadal. Tradition established the use of fly agaric by witch doctors of the Lapps of Inari in Europe and of the Yakagir of northernmost Siberia. Formerly, the narcotic employment of *Amanita muscaria* was apparently more widespread, and it has even been

The author is executive director and curator of economic botany, Botanical Museum of Harvard University, Cambridge, Massachusetts. He is also lecturer in economic botany, Biology Department, Harvard University.

suggested that the ancient giant berserkers of Norway induced their occasional fits of savage madness by ingesting this mushroom (*7*).

In Siberia, several mushrooms, often an expensive article of trade, suffice to cause an intoxication. They may be taken as extracts in cold or warm water or milk, either alone or with the juice of *Vaccinium uliginosum* or *Epilobium angustifolium*. Sometimes, a dried mushroom may simply be held, moistened, in the mouth. Among the Koryak, the women chew the mushrooms and roll them into elongated pellets which the men swallow. Many of these peoples have discovered that the intoxicating principles are excreted unaltered in the urine, almost as hallucinogenic as the original plant material. This discovery has given rise to the custom, sometimes ritually executed, of the inebriate's drinking his own or another's urine when he feels the intoxication waning, thus repeatedly effecting a continuation of the narcosis.

Effects of *Amanita muscaria* vary appreciably with individuals and at different times. An hour after the ingestion of the mushrooms, twitching and trembling of the limbs is noticeable with the onset of a period of good humor and light euphoria, characterized by macroscopia, visions of the supernatural and illusions of grandeur. Religious overtones—such as an urge to confess sins—frequently occur. Occasionally, the partaker becomes violent, dashing madly about until, exhausted, he drops into a deep sleep.

Since 1869, when muscarine was isolated, most workers have assumed that the toxicity and hallucinogenic properties of *Amanita muscaria* could be attributed to this alkaloid. Studies have shown, however, that muscarine is a minor constituent which could not be alone responsible. The same is true of the trace amounts of bufotenine reported in the carpophores. Recent pharmacological tests show that the central nervous system activity is due primarily to muscimole, an unsaturated cyclic hydroxamic acid, and to amino acids, ibotenic acid, and the less active muscazone. Since ibotenic acid is a precursor for muscazone, the variation in intoxication potential of the fly agaric may be due to fluctuations in the ratio between these two constituents. There is evidence that still other as yet uncharacterized principles may take part in the toxicity of this species (*8*).

About 3500 years ago, Aryan peoples swept from the north into India, bringing with them the cult of a plant called *soma*. They deified the plant as a holy inebriant, drinking its juice in religious rites. More than 1000 hymns to soma have come down intact in the Rig Veda. For over 2000 years, during which period the Aryans abandoned the original plant and forgot it, the identity of soma has been a deep mystery. For a century Western civilization has been puzzled by the identity of soma. More than 100 species have been suggested as its source, but none has gained acceptance. *Ephedra*, a gymnosperm, and *Periploca* and *Sarcostemma* (Asclepiadaceae) have been principal contenders—all fleshy, leafless or nearly leafless desert vines. Some botanists have felt that soma could have been *Cannabis*, others that it was wholly mythical and never was derived from a plant. The most recent identification of soma as *Amanita muscaria* appears to be the first that satisfies all of the many descriptive details and evidence gleaned from the Vedic hymns, and none seems to contradict it. If correct, it represents a meaningful contribution to ethnobotany in view of the extraordinary religious and social role of soma as emphasized in one of the earlier texts in the Indo-European world (*9*).

Another center of hallucinogenic use of mushrooms lies in Mexico. Archeological "mushroom stones" indicate that a sophisticated mushroom cult existed in Guatemala 3500 years ago. Early Spanish chroniclers wrote in detailed opposition to the diabolic mushrooms of the Aztec, *teonanacatl* ("food of the gods"), eaten ceremonially for divination, prophecy, and worship (Fig. 2); but since four centureis failed to produce evidence of such use of mush-

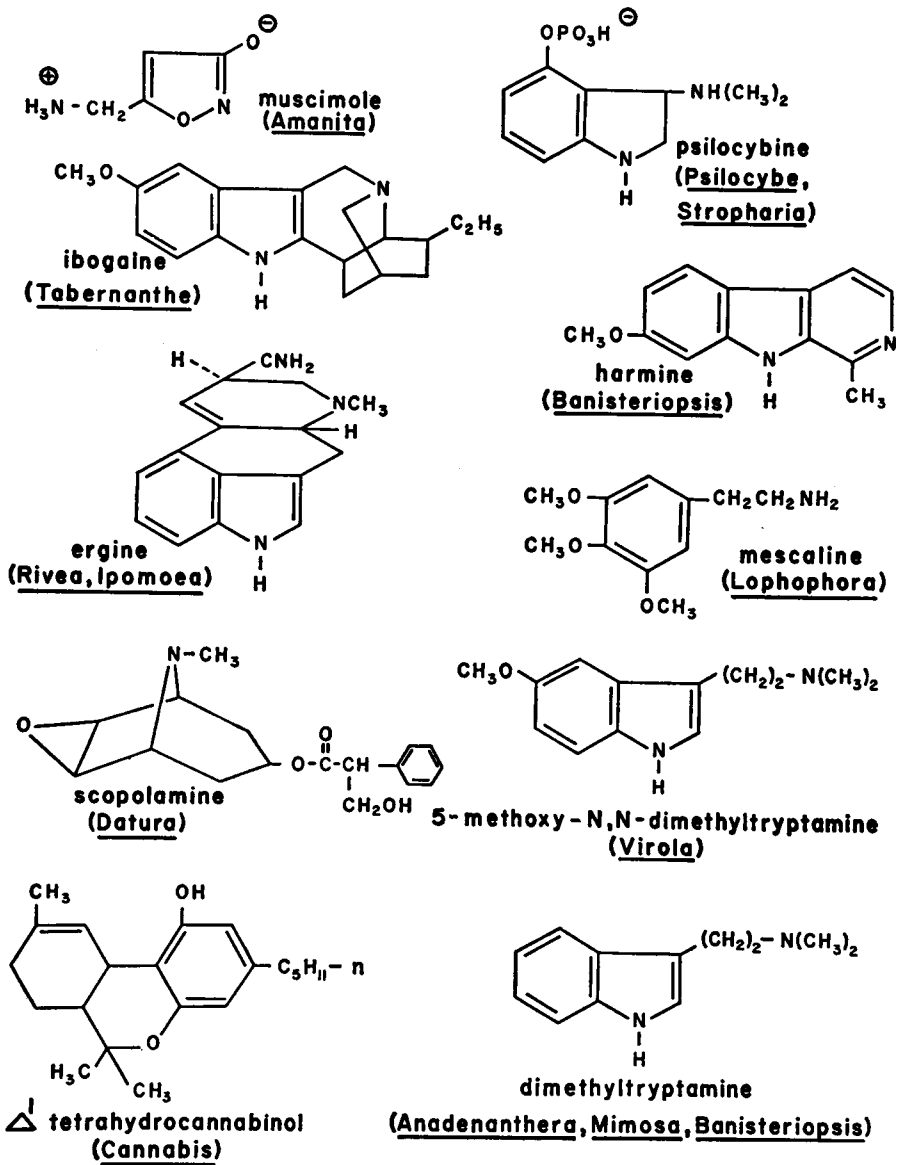

Fig. 1. Main hallucinating constituents of psychotomimetic plants.

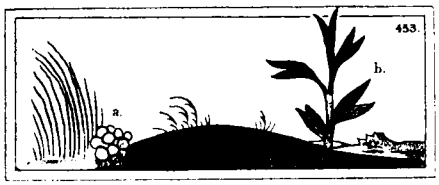

Fig. 2. An early illustration of the sacred hallucinogenic mushrooms of Mexico, teonanacatl. [From the Florentino Codex of Sahagún's *Historia de las cosas de la Nueva España*, written during the middle of the 16th century]

rooms, the suggestion that the chroniclers had confused the dried mushrooms with the dried crowns of the hallucinogenic peyote cactus was accepted. Only during the past two decades have ethnobotanical studies elucidated the extent of modern use in southern Mexico of at least 20 species of mushrooms in four genera among nine tribes. These mushrooms belong to *Conocybe, Panaeolus, Psilocybe*, and *Stropharia*, with *Psilocybe mexicana* perhaps the most important (*10*). Many, if not all, contain psilocybine, an extraordinarily biodynamic tryptamine with a phosphorylated side chain, and an unstable derivative psilocine (*11*).

Psilocybe yungensis has been suggested as the identification of a "tree fungus" reported by early missionaries as the source of an intoxicating beverage of the Yurimagua of Amazonian Peru. No evidence, however, points to the present use of an hallucinogenic mushroom in that area (*5*).

Among spermatophytes, hallucinogens are found throughout the dicotyledons, but the monocotyledons are notably poor in psychotomimetic properties.

Zingiberaceae

There have been vague reports of the hallucinogenic use of *Kaempferia galanga* in New Guinea, but, as yet, ethnobotanical and phytochemical corroboration are wholly lacking (*12*).

Moraceae

Perhaps one of the oldest known hallucinogens is *Cannabis sativa*, a member of a monotypic moraceous genus, sometimes, together with the hops plant, set aside in a distinct family Cannabinaceae (*13*). One of the most ancient of cultivated plants, this dioecious, weedy annual that may grow to a height of 15 feet (5.5 meters), is native probably to Central Asia. It is the source of hemp fiber, a seed oil, and a narcotic. Over the millennia, man has selected "races" or "varieties" of this cultigen with desired characteristics: some for stronger fiber; some for higher oil content; others for greater narcotic potency. Selection for narcotic activity has been especially notable in regions like India, where the inebriating properties had religious significance. Furthermore, it is recognized that the strength of the intoxicating principles in any given "race" of *Cannabis* will decrease as the plant is grown in more northern latitudes.

Hemp was reported in a Chinese document 3500 years ago. The Assyrians used the plant in 9th century B.C. as an incense. The Sanskrit Zend-Avesta first mentioned its intoxicating resin in 600 B.C. Herodotus wrote that the Scythians burned its seeds to produce a narcotic smoke. In Thebes, it was made into a drink with opium-like properties. Galen reported general use of hemp in cakes which, eaten to excess, were narcotic. In 13th century Asia Minor, the hashishins were political murderers who, excited to their nefarious work by ingesting hashish, a form of cannabis, would carry out murder for pay; from this Arabic term comes our word assassin.

Cannabis is probably the most widely disseminated hallucinogenic plant, now known in virtually all inhabited parts of the world, escaping easily from cultivation and growing spontaneously. Consequently, its narcotic use in sophisticated societies, especially in urban areas, has recently increased, presenting major legal, moral, social, and health dilemmas to European and American authorities. Its employment in primitive societies may shed much light on problems resulting from its use and abuse in more advanced communities.

Recent study has established that the euphoric and psychotomimetic activity of *Cannabis sativa* is due primarily to Δ^1-tetrahydrocannabinol (*11*) found concentrated in a resin abundant in the unripened fruits and adjacent leaves and normally absent from or sparse in staminate plants. Although much is known about the effects in man of crude *Cannabis* preparations, little is yet understood of the biological activity of pure tetrahydrocannabinol. Despite its long history as a therapeutic agent, especially as a sedative in the treatment of hysteria, it has disappeared

Fig. 3. *Virola*. [From *Rhodora*, p. 151 (see *15*)]

from the pharmacopoeias of most nations, since it is now considered to be medically valueless. The intoxication from abusive use of *Cannabis* preparations exhibits high variability but is characterized usually by an early onset of a dreamy state with confusion of thoughts, euphoric exaltation, and extreme happiness often alternating with abnormal depression. Visual and auditory hallucinations are common. Time perception is almost always altered. There may be nausea, dizziness, delusions of persecution and suffering, and rarely suicidal tendencies. Although not addictive, *Cannabis* may be definitely habituating. Dulling of the intellect and psychotic disturbances are often associated with excessive and continued use, but occasional use does not appear to be exceptionally deleterious.

Methods of taking *Cannabis* vary widely. In the New World, *marihuana* or, in Brazil, *maconha*—the dried, crushed flowering tops and leaves—are smoked, usually mixed with tobacco, in cigarettes. In parts of primitive Africa, *Cannabis* enjoys an important role in religion and magic. *Hashish*, the resin from pistillate flowers, is eaten by millions, especially in Moslem areas of North Africa and the Near East. It is in India, however, that *Cannabis* assumes extraordinary religious significance and where, as a result, man has selected "races" characterized by high concentrations of tetrahydrocannabinol. The ancient Atharva-Veda called it a "liberator of sin" and "heavenly guide," and it is still used in temples as a sacred plant. Three *Cannabis* preparations are

Fig. 4. Tree of *Anadenanthera peregrina* in the *campos* or open grasslands near Boa Vista, Rio Branco, Brazil. [Photograph by the author]

commonly employed narcotically in India. *Bhang,* the weakest, is the dried plant gathered green, powdered, and made into a drink with water or milk or, with sugar, into candies called *majun*; opium and *Datura* may often be added. *Ganja,* usually smoked with tobacco, but sometimes eaten or drunk as an infusion, consists of dried pistillate tops with exuded resin carefully gathered from cultivated or wild "races" especially rich in tetrahydrocannabinol. *Charas*, pure resin removed from leaves and stems, also from especially cultivated, strongly narcotic "races," is normally smoked. Cannabis is the drug of the poor of India, where, in addition to its religious use, it is valued in folk medicine and as an aphrodisiac; and hedonistically as an euphoric narcotic, especially in activities requiring endurance or physical effort.

Although the marked increase in smoking marihuana in the United States poses a variety of problems, much of the drug illicitly used at the present time in the United States is weak, since it consists not of the pure resin, but of crushed leaves, twigs, and tops of plants notably low in tetrahydrocannabinol. These plants grow spontaneously, spread mainly from hemp formerly cultivated in plantations for fiber, at one time a major agricultural industry in North America. Marihuana smuggled into the country from Mexico or other tropical areas represents usually a stronger and potentially more troublesome narcotic.

The Moraceae likewise provides one of the most poorly understood hallucinogens *Olmedioperebea sclerophylla,* a jungle tree, the fruits of which reputedly were the source of an intoxicating snuff employed formerly by Indians of the Pariana region of central Amazonia. No chemical study of this plant has been published, and direct observation of the preparation and use of the snuff has been impossible (see *2, 3*).

Aizoaceae

More than 225 years ago, the Hottentots were reported chewing the vision-inducing narcotic *khanna,* a name now applied in South Africa to species of *Mesembryanthemum,* several alkaloidal species of which can produce torpor when ingested. No direct evidence, however, connects the Hottentot khanna with *Mesembryanthemum*, and other plants—*Cannabis* and *Sclerocarya caffra* (Anacardiaceae)—have been suggested (*14*).

Myristicaceae

An important hallucinogenic snuff of sundry tribes of northwesternmost Brazil and adjacent Colombia and Venezuela is prepared from the reddish bark resin of several jungle trees of *Virola—V. calophylla, V. calophylloidea,* and *V. theiodora* (Fig. 3). The use of this snuff, called *yakee, paricá, epená,* or *nyakwana,* centers among the Waiká of Brazil and Venezuela, where it is made by drying and pulverizing the resin. Taken in excessive doses through a bamboo or bone snuffing tube and acting almost immediately, it sometimes has additional ingredients—the bark-ashes of *Elizabetha princeps* (Leguminosae) or *Theobroma subincanum* (Sterculiaceae) and, occasionally, powdered leaves of *Justicia pectoralis* var. *stenophylla* (Acanthaceae). Recent study has shown that *Virola* snuff contains high concentrations of tryptamines, especially 5-methoxy-*N,N*-dimethyltryptamine; and preliminary evidence suggests that tryptamines may be present also in *Justicia.* In Colombia, the snuff is taken only by witch doctors; among the Waiká, all adult males may employ it hedonistically at any time, and it is used excessively in endocannibalistic ceremonies. Effects include initial excitability, numbness of the limbs, twitching of the facial muscles, nausea, hallucinations, and, finally, a deep, disturbed sleep. Macroscopia is frequent and enters into Waiká beliefs about the spirits resident in the drug (*15*).

It is interesting that primitive American cultures have discovered these properties in *Virola,* since the related Asiatic *Myristica fragrans*—the common nutmeg—is hallucinogenic and is thought to have been employed narcotically in southeastern Asia. It is occasionally so employed in sophisticated circles in Europe and in the United States. The toxicology of nutmeg is still not completely elucidated but the effects seem to be attributable to several phenylisopropylamines among the many components of nutmeg oil (*16*).

Leguminosae

Several other South American snuffs are prepared from leguminous trees, wild or cultivated, of the genus *Anadenanthera* (*Piptadenia*) (*17*). The best known is *yopo* of the Orinoco area of Colombia and Venezuela, made from the toasted beans of *A. peregrina* (Fig. 4), usually with an alkaline admixture of ashes or calcined shells and causing, when blown into the nostrils, an intoxication marked by a temporary fury and trance accompanied by visual hallucinations and eventual stupor (*18*).

This snuff, known as *cohoba*, was once employed widely in the Caribbean. The earliest report dates from Columbus' second voyage in 1496. Many early writers confused cohoba with tobacco snuff (*19*). Five indoles have been isolated from seeds of this tree, chief of which are bufotenine and *N,N*-dimethyltryptamine (*20*). Anthropologists have often attributed most intoxicating South American snuffs to *A. peregrina*, even those employed in regions where the tree is unknown, but its use is circumscribed mainly to the Orinoco and peripheral areas (*21*). There is indirect, though weak, evidence that *A. colubrina* might have been the source of the narcotic snuff *vilca* or *huilca* of southern Peru and Bolivia and *cébil* of northern Argentina. This species, closely related to *A. peregrina*, possesses the same psychoactive constituents (*22*).

Yurema, an hallucinogen of the Kariri, Pankararú and other Indians of eastern Brazil, prepared from *Mimosa hostilis*, forms the center of a cult using an infusion of the root to bring on glorious visions of the spirit world (*23*). The active principle has been identified as *N,N*-dimethyltryptamine, an indole occurring in the closely allied genus *Anadenanthera*.

Sophora secundiflora, a shrub of dry areas of the American Southwest and adjacent Mexico, bears dark red beans known as "mescal beans" or "red beans." They contain a toxic pyridine—cytisine—causing nausea, convulsions, hallucinations, and occasional death from respiratory failure. A report by the Spanish explorer Cabeza de Vaca mentioned them as articles of trade among Texas Indians in 1539. The Stephen Long Expedition in 1820 reported the Arapaho and Iowa using large red beans as a medicine and narcotic. They have been found in archeological sites, all dated before A.D. 1000, sometimes with evidence of possible ritualistic use of the beans.

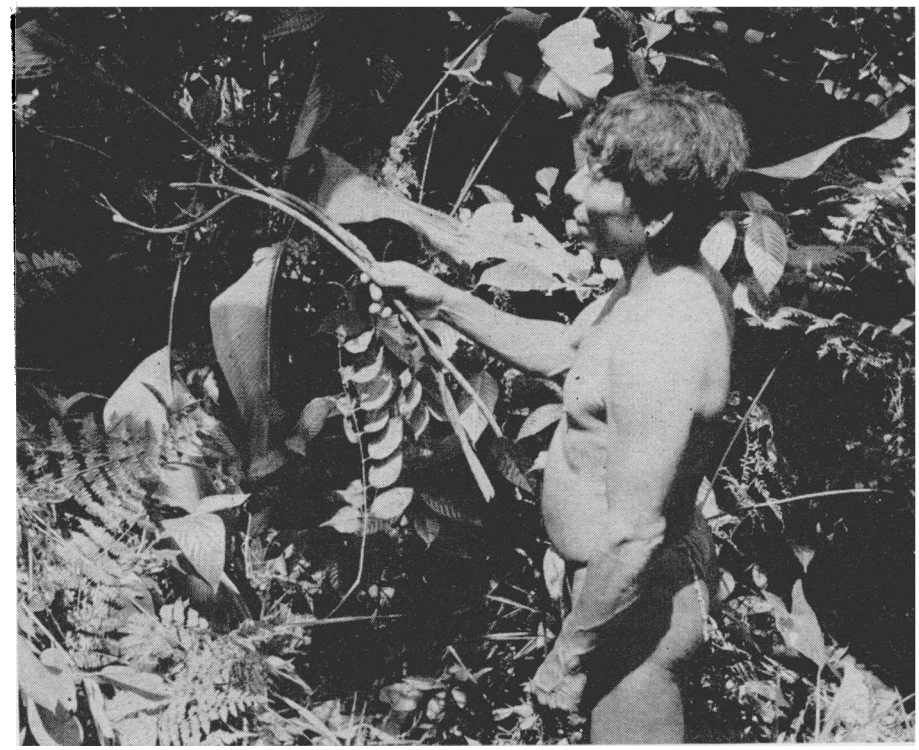

Fig. 5. A witch doctor of the Noanama tribe holding trunk and leaves of the dapá plant (*Banisteriopsis* sp.) from which an hallucinogenic drink is prepared. Near mouth of Calima River, San Juan drainage area, Pacific Coast, Colombia. [Photograph by G. Reichel-Dolmatoff]

Indian groups of Mexico and Texas formerly ingested these seeds in a ceremonial Red Bean Dance, and Plains Indians employed them as an oracular or divinatory medium, for visions in initiation rites, and as a ceremonial emetic and stimulant. The bean is still often worn as part of the ornamental dress of the leader of the peyote ritual, indicating possibly its earlier use as a narcotic, a role which it lost with the arrival of the much safer hallucinogenic cactus (*2–4, 24*).

The seeds of some species of *Erythrina* resemble the mescal bean and may have been valued as hallucinogens in Mexico, where they are called *colorines* and are often sold in markets mixed with *Sophora secundiflora*. Some species contain toxic indole or isoquinoline derivatives.

Several species of *Rhynchosia* may also have been employed as narcotics in ancient Mexico (*4*). In Oaxaca, the red and black beans of *R. phaseoloides* and *R. pyramidalis* are known as *piule*, a name locally signifying also the seeds of hallucinogenic morning glories of the region, and Oaxacan natives today recognize *Rhynchosia* seeds as toxic. An as yet uncharacterized alkaloid has been isolated from the genus. *Rhynchosia* seeds have been identified on Aztec paintings, together with mushrooms, suggesting that they may have been valued as hallucinogens.

A recent report of the hallucinogenic use of *Cytisus* (*Genista*) *canariensis* by Yaquí medicine men in northern Mexico has been experimentally substantiated (*25*). This species, member of an alkaloid-rich genus, is native to the Canary Islands, not Mexico, and contains cytisine, the psychoactive constituent of mescal beans.

Zygophyllaceae

An herb native to dry areas from the Mediterranean east to northern India, Mongolia, and Manchuria—*Peganum harmala*—possesses definite hallucinogenic properties in the alkaloid content of its seeds: harmine, harmaline, harmalol, and harman, bases known from at least eight families. This and other species of *Peganum* are highly valued in folk medicine. Although there have been vague reports of its hallucinogenic employment, its actual narcotic use to induce visions is open to doubt (*26*).

Malpighiaceae

The natives of South America have discovered in the related family Malpighiaceae a number of bizarre hallucinogens that likewise owe their activity to harmala alkaloids—several species of *Banisteriopsis* (Fig. 5) (*27*). From *Banisteriopsis caapi, B. inebrians,* and *B. rusbyana* and the related *Tetrapteris methystica,* Indian tribes in the western Amazon of Brazil, Bolivia, Colombia, Ecuador, and Peru, the Orinoco headwaters in Venezuela and the Pacific coast of Colombia prepare a psychotomimetic decoction or infusion variously known as *ayahuasca, caapi, natema, pinde,* or *yajé.* Usually, only one species is employed; but, in the westernmost Amazon, the preparation may involve the bark of *B. caapi* or *B. inebrians* and the leaves of *B. rusbyana.* Recent studies show that leaves of *B. rusbyana* are added to reinforce the hallucinogenic effects of the drink prepared from the bark of other species of the genus. The identification of yajé as *Prestonia amazonica,* although widely accepted, is wholly discredited (*28*). Other plants, some highly toxic, are sometimes added to *Banisteriopsis* drinks—*Alternanthera, Psychotria, Nicotiana, Datura,* and *Malouetia. Tetrapteris methystica,* with no admixture, is the source of a potent hallucinogenic drink in the Rio Tikié in Brazil; although no chemical studies on this species have been made, there is every reason to presume that its effects are attributable also to harmala alkaloids.

The chemistry of the malpighiaceous hallucinogens has, in general, been more critically investigated than the botany, yet failure of chemists to insist upon rigorous botanical determination of material analyzed has created chaos (*29*). An alkaloid in *B. caapi* was shown in 1928 to be identical with harmine isolated a century ago from *Peganum harmala.* Subsequent work has proven that the active bark constituents are harmine, harmaline, and tetrahydroharmine—all with a β-carboline skeleton, while leaves of *B. rusbyana* contain in addition dimethyltryptamines. Harmine has been found in *Cabi paraensis,* an eastern Amazon plant allied to *Banisteriopsis,* but, although valued in popular medicine, it is apparently not used as an hallucinogen.

Ayahuasca- or caapi-intoxication varies widely but normally begins with giddiness, nervousness, nausea, profuse perspiration leading to lassitude, listlessness, and detachment. The onset of color visions starts generally with a bluish or purplish aureole and, while sometimes these are the only colors experienced, red, green, and orange imagery is often rich, and lightning-like flashes of light are common; synesthesias may or may not be experienced. Muscular coordination is rarely altered; in fact, many Indian caapi ceremonies involve dancing. Occasionally, a deep sleep interrupted by dreams culminates the intoxication. The native takes caapi for divination, prophecy, diagnosis and treatment of diseases, communion with ancestors, preparation for war, male adolescent rites, and many other purposes. The drug represents, obviously, an ancient culture trait, and some Amazonian peoples treat it as a sacred, almost deified, element.

Caapi and ayahuasca were discovered more than a century ago by the British explorer Richard Spruce. Nothwithstanding a century of botanical study, this complex of narcotics offers still a most fertile field for interdisciplinary investigation which must be done soon because of the pace of acculturation in many areas of South America.

While *Banisteriopsis* is normally taken as a beverage, there is evidence that in the northwesternmost Amazon it may be used as a snuff as well: harmine, harmaline, and tetrahydroharmine have been reported from snuff powders prepared from a vine said to be the source also of a drink in the Rio Negro basin; botanically identifiable material, unfortunately, is lacking.

Cactaceae

The famous *peyote*—"prototype" of New World plant hallucinogens—is *Lophophora williamsii* (Fig. 6): a grey-green, spineless cactus with a small dome-shaped head bearing tufts of whitish hair and a long carrot-like root (*30*). The small chlorophyllous crown is sliced off and dried to form hard, brownish disks, known as mescal buttons. Keeping indefinitely without loss of intoxicating properties and transportable over long distances, mescal buttons are usually softened in the mouth and swallowed directly without chewing. Native to the deserts of central and northern Mexico, peyote claims centuries of use as a narcotic and was basic to pre-Columbian religious practices of the Aztec and other Mexican Indians. Much is known about the ancient religious use of peyote because of the many Spanish writings, all unsympathetic, attributing diabolic properties to the cactus. One religious questionnaire compared the ingestion of peyote with cannibalism. Primitive peyote religious dances still survive among the Cora, Huichol, and Tarahumare of northern Mexico. About 90 years ago, Plains tribes from the United States, especially Kiowa and Comanche, discovered the peyote cult on raids in Mexico, brought the sacred plant back and elaborated a wholly new cult—a combination of pagan and Christian elements—which spread rapidly throughout the Plains area, then to the Southwest and north as far as Saskatchewan. By 1922, the cult numbered 13,300 adherents and, for protection against fierce and unjust persecution from missionary and political circles, was legally incorporated into the Native American Church, now claiming 250,000 followers, which teaches reverence, high moral values, and abstinence from alcohol. Tribes near the source of peyote make ceremonial collection trips to get it; distant tribes secure their supply through the post by purchase.

Peyote was described as a new species of *Anhalonium* in 1888, and the first pharmacological studies were published the same year. In 1892, the anthropologist Lumholtz discovered it among the Huichol and Tarahumare and sent dried mescal buttons to Harvard University, upon which a definitive botanical identification was made. It represented a species first described in 1845 as *Echinocactus williamsii,* although later study showed that it deserved recognition as a distinct monotypic genus *Lophophora.*

Peyote contains at least 15 β-phenethylamine and isoquinoline alkaloids (*31*). All are active, but the most important one is mescaline. Peyote intoxication is highly complex and variable. Its most spectacular phase, for which mescaline is responsible, comprises the kaleidoscopic play of visual hallucinations in indescribably rich colors, yet auditory and tactile hallucinations and a variety of synesthesias are among the other effects. Consequently, the intoxications induced by mescaline and by peyote itself are very different, but they have unfortunately been confused in the literature. Most psychological experimentation has been based on

mescaline, whereas native religious rites have experiences resulting from the effects of all of the alkaloids together. While the visions are important in native cults, peyote is likewise revered as a sacred medicine, and curing rites are common in the ceremony.

Other cactaceous plants have been employed as hallucinogens, and evidence suggests that still others do possess psychoactive constituents. The Tarahumare use, in place of *Lophophora* for special religious and medicinal purposes, several species of *Mammillaria* and *Echinocactus*. Various species of *Ariocarpus, Astrophytum, Aztekium, Dolichothele, Obregonia, Pelecyphora,* and *Solisia* are popularly classed as peyote in Mexico, possibly because they resemble the true peyote but perhaps equally well suggesting a use similar to that of *Lophophora*. Alkaloids similar to or identical with those of *Lophophora* have been found in some of these Mexican genera (*6*). A large columnar cactus, *Trichocereus pachanoi*, the "San Pedro" of northern Peru, forms the basis of an hallucinogenic drink taken by witch doctors for diagnosis, divination, and to make oneself owner of another's identity. Several species of *Trichocereus* contain mescaline and other alkaloids (*31*).

Apocynaceae

Why the family richest in alkaloids—Apocynaceae—should be so sparingly represented among the hallucinogens remains an enigma. The natives of the wet tropical forests of West Africa, especially of Gabon, chew the yellowish root of *Tabernanthe iboga* to offset hunger and fatigue (*32*). In large doses, iboga causes excitement, mental confusion, and a drunken madness characterized by prophetic utterances. Its many uses in folk medicine in primitive African societies may be attributed to its 12 alkaloids, the principal one of which—the indole, ibogaine—has cocaine-like effects. Although ethnobotanical data reporting its use to induce visions are few and vague, there is some evidence that its ceremonial role, central to the Bwiti cult, seems to rest in part on its hallucinogenic properties.

The literature abounds with reports that *Prestonia* (*Haemadictyon*) *amazonica* is employed, under the name yajé, in the Amazon as an ingredient of an hallucinogenic brew—reports stemming from misinterpretation of botanical field data, careless identification, and even guesswork. Although this interesting genus of 30 tropical American vines is often considered toxic by the natives, little is known of its chemistry, only one species having been reported to contain an alkaloid of still undetermined identity. An analysis of leaves erroneously determined as *P. amazonica* (but belonging probably to *Banisteriopsis rusbyana*) indicated *N,N*-dimenthyltryptamine, an indole as yet unrecorded from the Apocynaceae.

An unidentified lacticiferous jungle liana, the root bark of which is employed, without the admixture of any other plant material, by remote Tanimuka Indians in Amazonian Colombia in preparing a strongly hallucinogenic drink used in male adolescent rites, may represent an apocynaceous species (*5*).

Convolvulaceae

The early Spanish chroniclers of Mexico reported on numerous occasions the religious use of the lentil-like seeds of the Aztec *ololiuqui*, a sacred, hallucinogenic vine with cordate leaves. Several illustrations of the plant—the best in a voluminous study of the medicinal plants, animals, and stones of "New Spain" by Hernández, personal physician to the King of Spain who worked in Mexico from 1570 to 1575—

Fig. 6 (left). A flowering plant of the peyote cactus, *Lophophora Williamsii*, with eight heads. [Photograph by the author]

De OLILIVHQVI, seu planta orbicularium foliorum. Cap. XIV.

OLILIVHQVI, quam *Coaxihuitl*, seu herbam Serpentis alij vocant, volubilis herba est, folia viridia ferens, tenuia, cordis figura. caules teretes, virides, tenuesq;. flores albos, & longiusculos. semen rotundum simile Coriandro, vnde nomen. radices fibris similes. calida quarto ordine planta est. luem Gallicam curat. dolores è frigore ortos sedat. flatum, ac præter naturam tumores discutit. puluis resina mixtus pellit frigus. luxatis aut fractis ossibus, & lumbis fœminarum laxis, aucto robore mirum auxiliatur in modum. Seminis etiam est vsus in medicina, quod tritum, ac deuoratum, illitumq; capiti, & fronti, cum lacte & *Chilli*, fertur morbis oculorum mederi. deuoratum verò, venerem excitat. Acri est sapore, & temperie, veluti & planta eius, impensè calida. Indorum sacrifici cum videri volebant versari cum Superis, ac responsa accipere ab eis, ea vescebātur planta, vt desiperent, milleq; phantasmata, & dæmonū obuersātium effigies circumspectarent. qua in re Solano maniaco Dioscoridis similis fortasse alicui videri possit.

Fig. 7 (above). Reproduction of the earliest illustration and detailed discussion of the uses of the Mexican morning glory ololiuqui *Rivea corymbosa*. [From Francisco Hernandez' *Rerum medicarum Novae Hispaniae thesaurus, seu plantarum, animalium, mineralium mexicanorum historia* (Rome, 1651)]

leaves no doubt that ololiuqui represented a morning glory (Fig. 7). Most of the chroniclers were ecclesiastical authorities who railed against this "diabolic seed," and Christian persecution drove the native cults into hiding.

Corroboration of the identity of ololiuqui waited for 400 years, since no morning glory was found employed in pagan religious rites. The apparent absence of hallucinogenic use of a convolvulaceous plant, together with the fact that no intoxicating constituent was known to exist in the family, led ethnobotanists to assume that ololiuqui must have been one of the several narcotic species of *Datura*—despite the insistence of reliable Mexican botanists that the plant was a morning glory. This theory gained quick acceptance and persists even today, partly because tubular flowers of the Convolvulaceae and those of *Datura* are rather similar and partly because the syndromes of ololiuqui- and *Datura*-intoxication coincided well. Only in the late 1930's was actual voucher botanical material of a morning glory employed as an hallucinogen collected in Mazatec country in Oaxaca, and the accuracy of the ancient reports seemed to be vindicated by modern fieldwork (*33*). Later, another psychotomimetic morning glory—*badoh negro* of the Zapotec of Oaxaca—was found to represent *Ipomoea violacea* (Fig. 8) (*34*).

Among the natives of Aztec Mexico, ololiuqui was used for divination perhaps even more than peyote and teonanacatl. Hernández wrote that: ". . . when the priests wanted to commune with their gods . . . ," they ate ololiuqui seeds, and ". . . a thousand visions and satanic hallucinations appeared to them. . . ." Believed to possess a deity of its own, this plant was an ingredient also of magical ointments and enjoyed an exalted place in Aztec medicine. Modern Indians grind the seeds on a stone, soak them in water or alcoholic drinks, and filter them; ingest the filtrate, since the hard impervious testa may otherwise allow the seeds to pass intact through the digestive tract.

Chemical elucidation of the activity of these convolvulaceous hallucinogens awaited another quarter of a century. A few seeds of *Rivea corymbosa* were early subjected to preliminary pharmacological study and shown to be capable of inducing a "half narcosis" in frogs, but no active crystalline principle could be

Fig. 8. *Impomoea violacea.* [From *Harvard Univ. Bot. Mus. Leafl.* **20** (1963), plate xxx]

isolated, despite the ability of psychiatrists to produce hallucinations in man with the seeds. Finally, in 1960 and subsequently, chemical analysis proved that the psychotomimetic constituents of the seeds of these morning glories are alkaloids identical with or related to those known from ergot (*Claviceps purpurea*), a fungus of long medical history in Europe—chanoclavine, elymoclavine, ergine, ergometrine, isoergine, and lysergol. The principal components of these indoles are *d*-lysergic acid amide acid and *d*-lysergic acid methylcarbinolamide, ergoline derivatives closely allied to lysergic acid diethylamide, the famous hallucinogen LSD (*11*).

Fig. 9. *Salvia divinorum.* [From *Lloydia* **29** (1966), fig. 4]

Recent further phytochemical work has indicated relatively large amounts of ergoline alkaloids in additional species of *Ipomoea* and in other genera such as *Argyreia* and *Stictocardia* (*35*). The unexpected discovery of lysergic acid alkaloids known only from lower fungi in one of the evolutionarily most advanced families of the Metachlamydeae is chemotaxonomically of great interest.

Labiatae

The discovery of narcotics in the Mint family in both hemispheres is interesting. Crushed leaves of *Salvia divinorum* (Fig. 9) yield a drink employed by the Mazatec of Oaxaca, Mexico, in their divinatory rites, especially when sacred mushrooms or morning glory seeds are unavailable (*36*). Known locally as *hierba de la Virgen* or *herba de la Pastora*, this mint may represent the hallucinogenic *pipiltzintzintli* of the ancient Aztec, in which case it bespeaks a long history of narcotic use. The Mazatec likewise are said to employ as hallucinogens the leaves of *Coleus pumila* and *C. blumei*, both Old World introductions from southeastern Asia. Chemists have yet to find a toxic principle in *Salvia divinorum*, although investigators have experimentally substantiated the psychoactive effects of the plant. Chemical studies of the two species of *Coleus*, at least on the basis of the material growing in southern Mexico, have not been carried out, although other Old World species valued in folk medicine have been investigated. An interesting intoxicant of Turkestan tribesmen, *Lagochilus inebrians* (*37*), toasted leaves of which are taken with honey or sugar, contains a polyhydric alcohol, responsible apparently for its narcotic effects.

Solanaceae

One of the richest alkaloidal families, the Solanaceae, contains a number of plants that have been put to use as hallucinogenic agents.

Perhaps the most important genus is

Datura, certain species of which have been recognized since classical times as poisons and narcotics, eventually entering into religious and magical rites or valued in witchcraft and sorcerers' potions (*2–4, 14, 38*). Parts of the plants, especially of *D. fastuosa*, were smoked for pleasure, often with *Cannabis*, alcohol, or tobacco, for their hallucinatory properties in Asia and Africa. *Datura* was even more widely prized in the New World. Pre-Columbian Mexicans valued *D. meteloides* and *D. innoxia*, among other species, as medicinal plants and for use in divination as hallucinogens. This use of *toloache* (*Datura*) has persisted in northern Mexico even today in the hinterlands, despite its extreme toxicity. It is still known in the American Southwest, where many tribes (Navaho, Yokut, Yuman, Paiute, and others) employ the seeds, roots, and leaves, usually as a beverage, either in adolescent or divinatory rites, for diagnosis or directly for visionary effects; the Zuñi use *Datura* extensively as a narcotic, and their priests, who commune with the feathered kingdom at night, put powdered root into their eyes, ears, and mouth or, to commune with the dead or to bring rain, chew the root. The Indians of northeastern North America made limited narcotic use of jimson weed, *D. stramonium*.

In South America, *Datura* is represented by arborescent species forming a subgenus, *Brugmansia*, native to the Andean highlands from Colombia to Chile—*D. arborea, D. aurea, D. candida, D. dolichocarpa, D. sanguinea*, and *D. vulcanicola;* and in the warmer lowlands, *D. suaveolens*. Handsome trees with large, showy flowers and well known in horticulture, they are chromosomally aberrant cultigens, unknown in the wild state, and have been associated with man from earliest times, probably because of their medicinal and narcotic properties. Some have been of inestimable importance to ancient Andean civilizations.

The preparation and use of *Datura* differ widely in areas of South America, but it is frequently taken in the form of pulverized seeds dropped into fermented *chicha* or as an infusion; leaves or twigs likewise may be used. The intoxication is marked by initial violence so furious that the partaker must be restrained pending the onset of a deep, disturbed sleep during which hallucinations interpreted as spirit visitations, enabling the witch doctor to diagnose disease, discover thieves, and prophesy the future of tribal affairs and aspirations, are experienced. The Jivaro value *Datura* for correcting refractory children who are given the seeds in the hope that the spirits of their forefathers may come to admonish them. The ancient Chibcha of the Bogotá area gave wives and slaves of deceased chieftains potions of *Datura* to induce stupor prior to their being buried alive with their departed master. The Siona of today frequently mix *Datura* leaves with *Banisteriopsis* in preparing yajé.

Fig. 10. A flowering branch of one of the atrophied cultivated types of *Datura candida*, the "variety" locally known as "amarrón borrachera" in Sibundoy, Colombia. [Photograph by the author]

Accurate information on the species used by tribes for special purposes is not available, but since most, if not all, species of *Datura* of North America and the Old World, as well as the *Datura* tree species of South America, contain similar tropane alkaloids—hyoscyamine, scopolamine, and atropine—this does not pose the problem that it might wtih certain other hallucinogens.

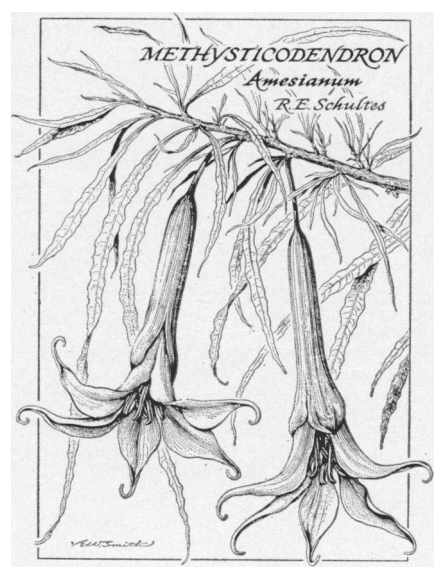

Fig. 11. *Methysticodendron amesianum*. [From *Harvard Univ. Bot. Mus. Leafl.* **17** (1955), plate I]

The Kamsá of Sibundoy in the Colombian Andes are extremely narcotic-conscious, employing several species and numerous named clones of these species, vegetatively perpetuated and so highly atrophied that they may possibly represent incipient varieties. Some of these clones or "races" are such monstrosities (Fig. 10) that their identification to known species has defied efforts, although the Indians have very definite native names for them. Differing in their narcotic strength, they are valued by witch doctors for different purposes. An extreme variant of an indeterminate species of tree *Datura* has been described as a distinct genus *Methysticodendron amesianum* (Fig. 11). Known by the native name *culebra borrachera*, this beautiful tree, endemic apparently to the high Sibundoy Valley, is stated by the Indians to be far more potent than any *Datura*. Whether or not this tree represents a distinct genus or an extremely monstrous cultivar of a *Datura* is still open to debate. Its chemical constitution includes *l*-scopolamine and hyoscyamine with very minor amounts of other alkaloids (*2–4*).

Although the narcotic use of *Datura* has been recognized from early times, the genus still constitutes botanically, ethnobotanically, and phytochemically a field for productive investigation.

Evidence for the former narcotic use on the eastern slopes of the northern Andes and elsewhere of *Brunfelsia*, a genus phylogenetically close to *Duboisia*, is quite real but is not yet corroborated by field evidence and observation (*5–6*). Numerous herbarium collections of *Brunfelsia* from Bolivia, Brazil, Colombia, Ecuador, and Peru indicate a broad spectrum of therapeutic uses in folk medicine, especially to relieve rheumatic pains, and one species, *B. hopeana*, is official in the Brazilian pharmacopoeia. Several herbarium collections refer to its use as a narcotic. *Brunfelsia*, a tropical New World genus of up to 25 species, is known to be toxic, and since several alkaloids, probably tropanes of indeterminate structure, and the coumarin compound scopoletine have been isolated from

this genus, it probably does possess hallucinogenic and otherwise biodynamic constituents.

A century ago, attention was drawn to the narcotic *arbol de los brujos* or *latué—Latua pubiflora*—a spiny solanaceous shrub endemic on the Chilean coast and employed by the Indians as a virulent poison capable of causing delirium and hallucinations. Very little of a botanical and ethnobotanical nature is known about latué, and its chemistry is not well understood (*39*).

Henbane (*Hyoscyamus niger*) has been known from early classical times in the Mediterranean area as a poison and narcotic capable of causing permanent insanity. Fantastic visual hallucinations comprise one characteristic of the intoxication. This plant, containing atropine and scopolamine, became important in the conjuration of demons, prophecy, and soothsaying in European sorcery of the Middle Ages. *Hyoscamus muticus*, of Africa and Asia, with similar effect, is smoked as an inebriant in India. *Belladonna* (*Atropa belladonna*) and *mandrake* (*Mandragora officinalis*), both dangerous solanaceous poisons due to tropane alkaloids, may likewise have been occasionally employed in classical times or Europe of the Middle Ages for their hallucinating properties (*14*).

Compositae

The Mexican *Calea zacatechichi*, the leaves of which are taken in infusion for divination by the Chontal Indians of Oaxaca, is the most recently discovered hallucinogenic plant (*40*). Called *thle-pela-kano* or "leaf of god," it is believed to clarify the senses. Few chemical studies appear to have been made on this shrub.

In conclusion, Lewin's appraisal of man's search for hallucinogens may be appropriately pertinent (*14*): "The passionate desire which . . . leads man to flee from the monotony of everyday life . . . has made him instinctively discover strange substances. He has done so, even where nature has been most niggardly in producing them and where the products seem very far from possessing the properties which would enable him to satisfy this desire."

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